1.1 Introduction

The term building in civil engineering is used to mean a structure having various components like foundations, walls, columns, roofs, doors, windows, ventilators lifts various types of surface finishes etc.

As a civil engineers is mainly concerned with the construction of building, it is essential for him to acquire good knowledge of construction of various components of building.
1.2 Building

A permanent fixed structure forming an enclosure and providing protection from the elements.

A structure with a roof and walls is called a building.

Example: schools, houses, churches and factories are all buildings.

An area before or building the construction of a house is called building site.

1.3 Classifications Of Buildings As Per NBC (National Buildings Code)

As per NBC Buildings are classified into Nine groups based on occupancy as follows.

Group A: Residential Buildings.
Group B: Educational Buildings.
Group C: Institutional Buildings.
Group D: Assembly Buildings.
Group F: Mercantile Buildings.
Groups G: Industrial Buildings.
Groups H: Storage Buildings.

Groups A: Residential Buildings

These include any buildings in which sleeping accommodation is provided for normal residential purpose with or without cooking or dining or both facilities.

Examples: Lodging or rooming houses, one or two family private dwellings, Dormitories, Apartment houses (Flats) Hotels, Inns, Clubs, and Motels.

Group B: Educational Buildings

These include any buildings used for school, college used for educational purpose.

Example: Schools and Colleges.
Group C: Institutional Buildings

These include buildings which are used for the purpose, such as medical or other treatment or care of persons suffering from physical or mental illness, disease etc.

Example: Hospitals, Nursing homes, Jails, Prisons and Mental Hospital.

Group D: Assembly buildings

These include the buildings where groups of people assemble or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purpose.

Example: Theaters, Auditions, Exhibition Halls, Clubrooms, Passenger Station, Recreation Places etc.

Group E: Business Buildings

These include the buildings which are used for transaction of business (other than covered by group) for keeping accounts and record and similar purposes, services facilities etc.

Example: City Halls, Court Houses, Libraries etc.

Group F: Mercantile Buildings

These include the buildings which are uses as shops, stores, market either wholesaler or retail.

Group G: Industrial Buildings

These include the building in with products or materials of all kinds are fabricated, assembled and manufactured.

Example: Assembly plants, laboratories, power plants, smoke houses, refineries diaries and sew-mills.

Group H: Storage Buildings

These include the buildings for the storage of goods.

Example: ware houses, cold storage, store houses, truck and garages etc.

Group J: Hazardous Buildings

These include the building for storage, include manufacture for storage, handling, manufacture of explosive materials.
**Example:** (1) storage and handling of hazardous and highly inflammable liquids.

(2) manufacture of artificial flowers, explosives and fireworks.

### 1.4 Component Parts Of Building

A building generally consists the following structural components.

1. Foundation
2. Plinth
3. Walls and columns in super structure
4. Doors and Windows
5. Stills, lintel and sunshades
6. Roofs and upper floors
7. Steps and stairs
8. Finishes for Walls

![Figure 1.1 Cross section of wall](image)

- Parapet wall
- Sunshade and lintel
- Sill of windows
- Wall in the super structure
- Roof slab
- Weathering course
- Floor covering
- RCC roof slabs
- Floor covering
- C.C. Bed for supporting floor covering
- Sand filling
- C.C. Foundation

**Fig. 1.1 Cross section of wall**
Summary

• A structure with a roof and walls is called a building.

• An Area before or during the construction of a house is called Building site.

• As per National Building Code (NBC) buildings are classified into Nine Groups i.e Group A, B, C, D, E, F, H, and J.

• A building generally consist of the following structural components such as foundation, walls and columns, Doors and Windows, Sills, Lintels and Sunshades, Roofs and Upper Floors and Finishes for walls.

Short Answer Type Questions

1. Define Building.

2. Define Building site.

3. Mention the components parts of building.

Long Answer Type Questions

1. Explain in details with examples, the classification of buildings as per N.B.C.

2. State the different structural component of a building and indicate them an a neat sketch .

On Job Training

Visit different types of buildings and observes the component parts of building and maintain the record.
UNIT 2

Foundation

Structure

2.1 Definition.
2.2 Functions of foundation.
2.3 Bearing capacity of soil.
2.4 Essential requirement of good foundation.
2.5 Classification of Foundation.
2.6 Construction details of spread footing.
2.7 Wall Footing, Raft Foundation
2.8 Cause and importance of insecticides, pesticides and their treatments
2.9 Cause of failure of foundation and remedial measures.

Learning objectives

After studying this unit the student should be able to understand.

• About foundations
• Bearing capacity of soil
• Shallows, rafts and spread foundation.
• Cause of failure of foundations and remedial measures.
• Requirement of goods foundation.
2.1 Definition

Foundation is the part of the building constructed below the ground level and which is in direct contact with sub-strata and transmits all the loads to the sub-soil.

2.2 Functions of foundations

The foundation to be performed by the foundation are

1. To distribute the load coming on the structure over a large bearing area in order prevent any movement.
2. To distribute the load uniformly over the bearing surface so as to prevent unequal settlement.
3. To provide a level and firm natural bed for constructing the masonry over it.
4. To increase the stability of the structure.
5. To transit the loads of super structure to the soil safely.

2.3 Bearing capacity of soil

The load of the structure is coming on the soil and hence it is importance to know strength and behavior of the soil.

(1) Bearing capacity: The bearing capacity maybe defined as the largest intensity of pressure which maybe applied by structure or a structural member to the soil which support it, without causing excessive settlement or danger of failure of the soil in shear.

(2) Ultimate bearing capacity: ultimate bearing capacity is the mgross pressure intensity at the base of the foundation at which the soil fail in shear.

(3) Safe bearing capacity: ultimate bearing capacity is divided by a suitable factor of safety is called safe bearing capacity. The value factors of safety maybe 2 to 3 safe bearing capacity of soil (KN/M²).

\[
\frac{\text{ultimate bearing capacity}}{\text{factors of safety}} = \text{safe bearing capacity}
\]

2.4 Essential requirement of good foundation

Following are the three basic requirement to the filled by a foundation to be satisfactory.
1. **Location**: The foundation structure should be located such that it is future influence which may adversely affect its performance.

2. **Stability**: The foundation structure should be stable or safe against any possible failure.

3. **Settlement**: The foundation structure should not settle or defect to such an extent or the stability of building or the adjoining structure.

The above three requirements are independent of each other and for the foundation structure to be satisfactory, all the three conditions should be satisfied.

### 2.5 Classification of Foundation

Depending upon their nature and depth, the foundations are mainly classified.

As follows.

- **Foundations**
  - Shallow foundations
    - (a) Wall footing
    - (b) Isolated column footing
    - (c) Combined footing
    - (d) Cantilever footing
    - (e) Continuous foundations
    - (g) Raft or mat foundation
  - Deep foundations
    - (a) Pile foundation
    - (b) Well foundation

### Shallow Foundation

It is possible to construct foundation if building at reasonable shallow depth, the foundation are termed as shallow foundation.

In such cases, a spread is given under the base of a wall or column. This spread is known as footing and the foundation is known as spread footing. Shallow foundation are the most common type of foundations.
Deep Foundation

When the foundations have to carry heavy structural loads through a weak compressible soils, the foundations are taken deeper depths until a hard stratum is reached such foundations are called as deep foundation.

2.6 Construction details of spread footing

Design of spread foundation for a load bearing well consists of determining the following elements:

1. Depth of foundation
2. Width of foundation
3. Thickness of concrete bed.

1) Depth of foundation: Depth of foundation can be obtained by keeping following rules in views.
   (a) The depth of foundation for the load bearing wall should not be less than 900 mm even if hard stratum is available at similar depth.
   (b) Foundation depth can be determined using Ranker’s formula. The depth is based on the assumption that there will be no lateral movement in the soil due to pressure.

   \[ d = \frac{\gamma}{w} \left[ \frac{1 - \sin \phi}{1 + \sin \phi} \right]^2 \]

   Where \( d \) = minimum depth of foundation in metres.
   \( \gamma \) = safe bearing capacity of soil in kg/m² or kN/m²
   \( w \) = unit weight of soil in kg/cum or kg/cum
   \( \phi \) = angle of repose of the soil in degrees.

2) Width of foundation: The width of foundation is decided according to following rules.
   (a) If the wall is to directly rest on foundation block as shown in fig, the width of foundation should be equal to three times the thickness of the wall.
(b) The width of foundation should be twice the thickness of wall in superstructure plus twice the projection of the concrete bed from bottom most course of footing.

Hence \( B = 2t_w + 2j \)

Where \( B = \) Width of foundation

\( t_w = \) Thickness of wall in super structure

\( j = \) Projection of concrete bed from lower most course of footing.

(C) The width of foundation \( (B) \) can also found by dividing the total load coming from the structure per unit length of foundation by safe bearing capacity of the soil. If \( P \) is the load in tonnes or KN per metre length ; and \( \gamma \) is the safe capacity of the soil in \( t/m^2 \); then the width of foundation in metre if given by \( B = P/ \gamma \).

(3) Thickness of concrete bed

(a) The thickness or depth of C. C bed of the footing depends upon the projection of concrete bed beyond the footing over it, the upward soil pressure and the quality of concrete. The concrete bed may fail in bending, crushing or shearing. It is general practise to design the depth moment. The following formula may be used to determine the of concrete bed.

\[
t_c = \frac{L}{m} \quad ...... (i)
\]

\( t_c = \) Thickness of C.C bed in mm.

\( L = \) Load coming on the soil in KN/mm² = S.B.C. of the soil.

\( m = \) offset of C.C. Bed in mm.
\[ f_c = 0.003 \times \text{ultimate crushing strength of concrete after 28 days in } \text{kN/mm}^2 \]

(b) Thickness of concrete bed can also be found by the following thumb rule

\[ t_c = \frac{5}{6} t_w \]

\[ t_c = \text{Thickness of concrete bed in mm} \]

\[ t_w = \text{Thickness of wall in super structure in mm}. \]

**Example**

**Design the foundation for a building with the following data:**

- Load per meter run from the wall = 130 kN
- Safe bearing metre capacity of soil = 150 kN/m²
- Angle of repose for the soil = 30°
- Thickness of wall in super structure = 300 mm
- Specific weight of soil = 16 kN/cu.m
- Ultimate crushing strength of C.C. foundation = 15 N/mm²

**Solutions**

Using Rankine’s formula to find out the depends of foundation

\[ d = \frac{p - \frac{1 - \sin \phi}{1 + \sin \phi}}{w} \]

Where \( p = 150 \text{ kN/m}² \)

\[ W = 16 \text{ kN/cu.m} \]

\[ \phi = 30° \]

\[ d = \text{depends of foundation in metres} \]

\[ d = \frac{150}{16} \left[ \frac{1 - 0.5}{1 + 0.5} \right]^2 = \frac{150 \times 1}{16 \times 9} = 1.04 \text{ m say 1.1 m} \]
Hence adopt depth of foundation as 1.1 metres.

Assuming a concrete offset as 120 mm

Thickness of C.C foundation bed with concrete having ultimate strength of 15 N/mm²

\[ t_c = m \sqrt{\frac{L}{0.03 \times \text{ultimate strength}}} \]

Where \( m \) = Concrete bed offset in mm = 150 mm

\( L = \) Load carrying capacity of soil in kN/mm²

\[ = 150 \text{ kN/mm}^2 \]

\[ = 150 \times 10^{-6} \text{ kN/mm}^2 \]

Ultimate strength of C.C of foundation = 15 N/mm² = 15 x 10⁻³ kN/mm²

\[ t_c = \text{Thickness of C.C bed in mm} \]

\[ t_c = 150 \sqrt{\frac{150 \times 10^{-6}}{0.003 \times 15 \times 10^{-3}}} \]

\[ = 273.86 \text{ mm say 275 mm} \]

That is Hence provide thickness of c.c foundation bed as 275 mm

Width of foundation based on intensity of pressure \( B = \frac{P}{p} \)

Where \( P = \) load coming from walls in kN/metre

\( P = \) safe bearing capacity of soil in Kn/m²

That is \( B = \) width of foundation in metres.

\[ B = \frac{130}{150} = 0.0866 \text{ m say 0.9 metres} \]

Hence provide width of foundation as 0.9 m.

Since the breadth/width of foundation from thumb rule works out to be 0.9 m

i.e \( 2t_w + 2j \)

\[ = (2 \times 300) + (2 \times 150) = 900 \text{ mm}. \]
i.e. provide Depth of foundation = 1.1m width of foundation = 0.9m; thickness of c.c bed = 0.275m.

Setting out / Laying out plan of building

First of all, the site is cleared from all types of debris, plants shrubs etc. and then it is approximately levelled. At the time of foundation design, a foundation plan indicating the width of excavation along with other detailed dimension is prepared.

Second step is to mark the plan on the grown chunnam markings. Measuring tapes, wooden pegs, wooden squares, strings etc. are used to mark the plan on the ground. The corners of the building are marked first and the length of sides are checked by measuring the diagonals.

Now, the whole of foundation which is to be excavated is marked by the lime markings by lime markings. Some permanent markings are established near the corners of the building and other salient points. These should not be distributed during the excavation of the foundation trenches. Small brick pillars are constructed at a distance of about one metre from the edge of the excavation. Nails may be fixed at the top of the pillars for the exact measurement of the offsets, widths, and other distances on the foundation plan.

A theodolite is used in laying out the foundation plan of large buildings. The corner points and centre lines are fixed by this instrument. When the foundation plan is marked on the ground, the excavation of the earth is started by using ordinary excavating tools.
Fig. 2.3 Details of ground marking at a corner and brick pillars for reference

<table>
<thead>
<tr>
<th>Type of material</th>
<th>Horizontal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) In brick and stone masonry</td>
<td>1/2</td>
<td>1</td>
</tr>
<tr>
<td>(b) Lime concrete</td>
<td>2/3</td>
<td>1</td>
</tr>
<tr>
<td>(c) Cement concrete</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Special footings are the most widely used type among all foundations because they are usually more economical. Construction of footings requires a least amount a least amount of equipment and skill and no special equipment is necessary. Further, the conditions of footing and the supporting soil can be readily examined.

The various types of spread foundation are as follows which are constructed to spread the loads.

(a) Wall footing,
(b) Isolated column footing
(c) Combined footing
(d) Cantilever footing
(e) Continuous footing
(f) Grillage foundation

(g) Raft or mat foundation.

2.7 Wall footing, Raft Foundation

2.7.1 Wall Footing

Wall footings are either simple or spread. Simple footings are provided to carry light loads (ex: for compound walls). They have only one projection outside the width of the wall on both sides. The projection provided in the footing is 150 mm on either side and the depth of the concrete bed is at least twice the projections.

When the width of foundation is considerably more than the wall width, it is economical to make the brick footing stepped over a level concrete bed. The bricks are projected to one-fourth brick distance (about 50 mm) beyond the edge of the wall to increase the width of each footing. The footing should be designed properly otherwise, the upward reaction from soil will have a tendency.

(a) Isolated Column Footing: Isolated footing is provided under column to transfer the load safely to the soil bed. Column footings may have either steps or projection in the concrete base. When columns carry heavy loads, steel reinforcement is provided in both the directions in the concrete bed. An
offset of at least 150 mm is provided in the provided in the concrete bed on all sides.

(b) Combined Footing: The ideal situation for column foundations is to have a square column of the appropriate area with the column especially in developing sites in urban areas. In such place, the proposed structure situation would result in an eccentric column loading, if conventional isolated bases were employed.

Fig. 2.5

Fig. 2.6
In such cases, a combined column foundation consisting a reinforced concrete slab placed at right angles linking outer and inner columns is provided. The base slab of combined footing should have sufficient area to ensure that load per unit area will not cause over stressing of the soil. To prevent the possibility of eccentric loading, the centres of gravity of the column and foundation slab should be designed to coincide.

In situations, where the length of the slab foundation is restricted or where the outer column carries the heavier load, the shape of the slab in plan can be in the form of trapezium with the widest end located nearer to the heavier loaded column.

(c) Raft or Mat Foundation: This types of foundation is very useful when the load coming in the soil is practically uniform, while the soil is soft clay, made-up ground or marshy land with low bearing capacity. If there is any chance of settlements in the structure due to unpredictable behavior of sub-soil water condition, the use of raft foundation is recommended.

Thus, the advantages of raft foundation can be summarized as below:

1. It is most suitable foundation when the soil at the site proposed for the construction of a structure in erratic, soft and marshy having lot of compressible lenses. Raft foundation bridges the erratic deposits and eliminates the possibility of differential settlement.

2. Overall settlement of the structure is reduced, as the total load of the structure is distributed over large area and thus intensity of pressure on the foundation soil is reduced to minimum.
(3) Distribution of load on erratic area of foundation for a distance of about 300 mm to 500 mm all round the structure.

This projection remains embedded under the soil. This arrangement provides a sort of anchorage to the structure with foundation soil. Raft foundation is constructed of reinforced cement concrete slab not the force i.e., top and bottom. When the columnn loads are heavy, the main beams and secondary beams are provided monolithickly with the raft slab.

![Fig. 2.8 Raft Foundation](image)

The area of excavation is slightly more than the area of the structure, since the slab is projected beyond the outer walls of the structure. After excavation the soil up to the required depth, the foundation bed is well rammed. Over this surface the proper reinforcement is laid giving sufficient cover on all the sides. The concrete is poured over the prepared surface. It is well compacted and crude. All the precautions of reinforced concrete construction is observed.

2.7.2 Deep Foundation

Pile foundations and well foundations which come under deep foundations are described in detail in this volume.

Pile Foundation: A pile may be defined as a long vertical load transfer element composed of timber, steel, concrete or a combination of them.
The main function of piles is to carry the load of the structure which cannot be sufficiently supported at a certain level due to its poor bearing capacity to a depth at which good bearing capacity is available.

**Types of Piles:** In general, there are two types of piles.

1. **Bearing Piles:** When a pile passes through poor material and its tip (bottom end) penetrates a small length into a stratum of good bearing capacity, then it is called a bearing pile.

   The hard stratum or bed rock must be at a reasonable depth and there should be no too soft stratum below the hard stratum. Bearing piles transfer their load to the hard stratum.

2. **Friction piles:** When a pile passes through deep strata of limited bearing capacity and develops its carrying capacity by friction on the sides of the pile (circumference of the pile), then they are called friction piles. The friction pile derives its support mainly from the surrounding soil through the development of friction between the soil and the periphery of the pile.

   A very small percentage of the load is carried by the soil near the lower tip of the pile. Friction piles are used when hard stratum of bed rock is at a large depth. The length of friction pile depends upon the type of soil, amount of load and the size of pile.

3. **Other Piles:** Besides these two main types of piles, there are a number of the pile. Friction piles are used for specific purposes. They are compaction piles, Anchor piles, Dolphin and Batter piles.

   Compaction piles are used to compact loose granular soils by increasing the bearing capacity. When friction piles are driven in coarse grained soil, the process of driving such piles close to each other in group greatly reduces the porosity and compressibility of the soil within and around. Thus they compact the soil.

   Compaction piles do not carry any load themselves.

   Tension piles anchor down the structure which are subjected to or due to overturning movement.

### 2.7.3 Stepped Foundations

When the ground is sloping, it becomes uneconomical to provide foundation at the same level. In such cases, the correct levels of the sloping ground in which the building is to be constructed are taken and a longitudinal section
is prepared accordingly. The stepped foundation are then provide as shown in fig. 2.9.

Following points should be noted:

1. The overlap between two layers of foundation concrete should be equal to the depth of foundation concrete or twice the height of the step, whichever is greater.

2. A minimum depth of 800 mm should be provided at all points so as to protect the foundation from weathering effects.

3. The depth of foundation concrete should be in even number of the masonry course.

4. The distance of the sloping surface from the lower edge of the footing should not be less than 600 mm for rock and 1 m for soils.

5. When footings are heavily loaded, it becomes necessary to carry out a slope stability analysis.

2.8 Causes and importance of insecticides, pesticides and their treatments

2.8.1 Dampness - Introduction

Dampness in a building leads to unhealthy conditions and unsafe from structural point of view. Therefore one of the essential requirement is that the structure should be dry as far as practicable. To check the entry of water or moisture into a building, damp-proof course are placed at various levels. Now
a-days, all the buildings are provided with damp-proof course to prevent dampness from affecting a building or the person living in the buildings.

**Cause of Dampness**

Absorption of water by poor quality materials, is the chief source of dampness. Granular materials absorb water easily and this and this water may find access, to the inside of building in one way or other. Following may be the possible causes responsible for entry of dampness into a structure.

1. **Orientation of the building**: The walls getting more frequent splash of water, and less sunshine during the hotter part of the day are affected by dampness. Due to certain geographical conditions of the orientation of the buildings also plays an important role in damp prevention.

2. **Rain Water**: The rain water can directly penetrate from roof or its various components such as gutter, dormer windows etc. The dampness can also enter into the walls from its exposed faces which are subjected to heavy showers of rain and are properly protected against dampness.

3. **Exposed tops of wall**: Dampness-proof course should be provided at the top of boundary walls and parapet walls to check the entry of water through the top of walls, otherwise the dampness may cause serious damage.

4. **Rise of Ground Moisture**: Moisture from wet ground may rise well above ground level due to capillary in flows is caused due to this reason.

5. **Condensation**: Cool air can contain lesser amount of water vapour than warm air. Hence the moisture is depicted on the walls, roofs, etc., when warm humid air is cooled. This process is known as condensation.

6. **Poor drainage of the site**: In low lying areas, water cannot be easily drained off and creates water logging in impervious soil is encountered beneath the building. The dampness will prevail in the structures located in such areas.

7. **Bad Workmanship**: Defective construction of the joints in the roofs, throat of soil and copings, fixture in the buildings etc., causes dampness by allowing entry of the water inside the building. If proper slope entry of the water inside the buildings. If proper slope is not provided in the roof, rain water gets accumulated on the roof, and thus causing dampness.

**2.8.2 Effects of Dampness**

The main effects are as follows:

1. It create unhealthy condition for the occupants of the building.
(2) It causes efflorescence which may finally result in the disintegration of bricks, tiles etc.

(3) Plaster become soft and crumbled.

(4) It cause warping and decay of timber.

(5) The metals used in the construction of the building are subjected to corrosion.

(6) It causes blistering, bleaching and flaking of paints.

(7) Electrical insulation are damaged.

(8) The floors covering materials are deteriorated.

(9) Termite grows faster and dampness becomes the source for mosquito breeding.

Method of Termite-Proofing:

The methods of termite mentioned below are applicable to the subterrances termites only which cause serious damage to the buildings. The drywood termites can be effectively controlled by using preservatives-treated timber. The methods of termite proofing can drywood termites can be effectively controlled by using preservatives-treated timber. The methods of termite proofing can broadly be classified into the following two groups:

(i) Soil treatment with chemicals

(ii) Structural

(10) Soil treatment with chemical The soils insecticied atre thoroughly mixed and well spread in soil so as to provide an effective barrier for termite . The various patented chemicals insecticides such as DDT, BHC, PCP, etc. are available but the following chemicals in oil solution or preferably water emulsion have proved to be successful.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td>0.5 per cent</td>
</tr>
<tr>
<td>Chlordane</td>
<td>1.0 per cent</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>0.5 per cent</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>0.5 per cent</td>
</tr>
</tbody>
</table>

The above concentrations are by weight. All chemicals are chlorinated hydrocarbons. They are insoluble in water and hence they are not leached out by the subsoil water. The application of these chemicals serve as a chemical
barrier between the building and the ground and this method has proved to be the most effecting method of termit-proofing.

The soil treatments with chemical should start when the foundation trenches are ready to take mass concrete in foundation. The laying of mass concrete should start when the chemical emulsion has been absorbed by the soil and the surface is dry. The treatment should not be carried out when it is raining or when the soil is wet with rain or subsoil water.

The chemical solution be uniformly spread and for this purpose, a suitable hand operated compressed air sprayer or vessel containing water should be used.

All the soil insecticides are poisonous. There will be adverse effects if these chemicals are absorbed through skin, in held as vapor or swallow. It is therefore necessary to follow strictly the precaution mentioned on the containers of insecticides.

(2) Structural barriers: To prevent the entry of termites through walls, the impenetrable physical structural barriers may be provided continuously at Plinth level. Such structural barrier may be in the form of a cement concrete layer or metal layer at Plinth level. The cement concrete layer or coping is 50mm to 75 mm thick and it is preferable to keep it projecting about 50 mm to 75 mm internally and externally. The metal barriers consist of sheets of non-corrodible metals such as copper or galvanized iron, having a thickness of about of about 0.80 mm. The metal barrier are likely to be damages and may then prove to be inefficient against termites.

2.9 Causes of failure of foundation and preventive measures

The main cause of failure of foundation are as follows:

(1) Unequal settlement of the sub-soil
(2) Unequal settlement of the masonry
(3) Withdrawal of moisture from the sub-soil
(4) Lateral pressure on the superstructure
(5) Horizontal movement of the earth
(6) Transpiration of trees and shrubs
(7) Atmosphere action.
We will now discuss each one in details together with the measures to be taken prevent such failures.

(1) **Unequal Settlement of the sub-soil**: This occurs due to various reasons such as unequal distribution of load on the foundation, varying bearing power of the sub-soil, eccentricity of the load, etc. Due to unequal settlement of the sub-soil, the crakes are formed in the buildings, which in future, leads to serious defects.

Following are the measures to be adopted to prevent such failure:

(i) The foundation should rest on the rock or hard morim

(ii) The design of foundation should be appropriate to the nature of sub-soil.

(iii) It should be seen that the allowable bearing pressure on the soil is not exceeded, even under the worst conditions.

(iv) The proper attention should be given to the eccentricity of the loads on the foundations and design should be accordingly modified.

(2) **Unequal settlement of the masonry**: The mortars used as the building material in the masonry construction shrink sand gets compresses when loaded excessively before it has fully set. This may lead to the unequal settlement of the masonry and the measures to avoid such situation are as follows:

(i) The mortar to be used in the masonry should be stiff in line with the workable desired.

(ii) The masonry work should be raised evenly.

(iii) The height of wall to be raised day should be limited to one metre, if lime mortar is used and to 1.50 metres, if cement mortar is used.

(iv) The proper watering or curing for a period at least 10 days should be done to the masonry works to ensure the development of adequate strength of the mortar joints.

(3) **Withdrawal of moistures from the sub-soil**: This occurs at places where there is considerably variation in the height of water table. When water table falls, the soils particles loose cohesion and hence, there is shrinkage of soils, resulting in the crackes to the buildings. The precautions to be taken to avoid such failure would be to drive piles upto the hard rock.

(4) **Lateral pressure on the superstructure**: The thrust of a pitched roof or arch action on the superstructure causes wall to overturn. The remedial
measures to prevent this failure would be to provide a sufficient wide base and to design the foundation for the worst conditions.

(5) **Horizontal movement of the earth**: Very soft soil is liable to give way under the action in load, especially at places such as sloping ground, river banks, etc. Hence, in such cases, it is desirable to construct the retaining walls or to drive sheet piles to prevent the escape of the earth.

(6) **Transpiration of trees and shrubs**: The roots of trees planted near a building may absorb the moisture. This effect is seen in the form of a depression on the ground and it may lead to cracks in the building. The remedial measures are as follows:

(i) The foundation should be taken sufficiently deep. A minimum depth of one metre is required for this purpose.

(ii) The fast-growing and water-loving trees should not be planted near the building with a minimum distance of 8 metres.

(7) **Atmosphere action**: The rain and sun are main atmosphere agents to seriously affect the foundation of a building. The heavy rains or considerable variation in temperature or frost action may damage the foundations. The rainwater may create pockets near the walls and while descending, it may carry chemical and salts obtained from sewage, animal dung, etc. These chemicals may react with the material used for the foundation work and turn them into powder. The remedial measures to be taken are as follows:

(i) The foundation should be taken beyond the depth up to which rain can reach.

(ii) Suitable underground drains should be provided to maintain the water table at a definite level.

(iii) After the masonry work is completed, the sides of trenches should be carefully filled with earth and well-consolidated. A gentle slope should be provided so as to keep rain water from the wall.

**Summary**

- Foundation is the lowest part of the superstructure, which transfers the load of the superstructure to the subsoil.

- Superstructure is used to mean that part of the structure which is above ground level.

- A part of the superstructure located between the ground level and the floor level is known as Plinth.
• The basic function of the foundation is to transmit the expected loads safely to the soil.

• Ultimate bearing capacity divided by a suitable factor of safety is called safe bearing capacity of soil.

• Essential requirements of good foundations are 1. Location 2. Stability 3. Settlement.

• Shallow foundations are the most common type of foundations.

• Shallow foundations are provided for structure of moderate height built on soils having satisfactory amount of bearing capacity.

• Wall footings are simple or spread. Simple footings are provided to carry light loads i.e. for compound walls.

• Isolated footing is provided under column to transfer the load safely to the soil bed.

• Raft foundation is very useful when the load coming on the soil is practically uniform, while the soil is soft clay, made-up ground or marshy land with low bearing capacity.

• Design of spread foundation

\[
d = \frac{p}{w} \left[ \frac{1 - \sin \phi}{1 + \sin \phi} \right]^{\frac{2}{\phi}} \\
\]

\[
\text{Width of Foundation (B)} = 2tw + 2j \\
\]

\[
\text{Thickness of Concrete Bed (tc)} = \frac{L}{\phi} \\
\]

(\text{or})

\[
tc = \frac{5}{6} tw \\
\]

When the ground is sloping, it becomes uneconomical to provide foundations at the same level. In such cases the stepped foundations are provided.

Causes of failure of foundations are

1. Unequal settlements of the sub-soil.
2. Unequal settlement of the masonry.
3. Withdrawal of moisture from the sub-soil.
4. Lateral spressure on the superstructure
5. Horizontal movement of the earth.
6. Transmission of trees and shrubs.
7. Atmospheric action.

The following three important treatment to be given to the buildings to control damp water leakage and termites 1. Damp-proofing 2. Water proofing 3. Termite proofing.

**Short Answer Type Questions**

1. Define the term “Foundation”
2. Define the terms
   a. Ultimate bearing capacity of the soil.
   b. Safe bearing capacity of the soil.
3. Write the functions to be performed by a foundation of a building.
4. List the type sof foundations that are included in shallow foundations.
5. Draw a neat sketch of wall footing.
6. Draw a neat sketch of Isolated column footing.
7. List the types of foundation that are included in “Deep-foundation”.
8. Define Damp-proof course.

**Long Answer Type Questions**

1. Explain the requirements of good foundation
2. Draw a neat sketch of Raft foundation and explain.
3. Explain effect of dampness in a building.
4. What are the causes of dampness in a building.
5. Explain the method of termite proofing.
6. Explain the design of spread foundation.
7. Explain stepped foundation.
8. Explain the causes of failure of foundations and preventive measures.

**On Job Training**

1. Visit different types of structures which are under construction.
2. Observe and record the data of different types of foundation.
3.0 Introduction

Men learnt to utilize stones for their needs since the beginning of the civilization. Thus stone is used for construction from the beginning of human settlement. Stone masonry is used for the construction of foundations, walls for simple structures to various Architectural master pieces like Taj Mahal and wonders of the world like Pyramids. The stone masonry in this chapter covers...
the various types of stone masonry and the points to be remembered while supervising its construction.

### 3.1 Stone Masonry

#### 3.1.1 Definition

Stone masonry is the art of systematic arrangement of stones, bonding them together with mortar, to form a homogenous mass.

#### 3.1.2 Materials required for stone masonry

The materials required for stone masonry are stone and mortar.

**Stone**: Depending upon the availability and architectural appearance required, stones are selected. The stones used for the work should be hard, durable, tough and free from any defects.

**Mortar**: The mortar is required to keep the stones in position. It is prepared by mixing cement or lime with sand. Water is added to this mixture to form mortar. This mortar is placed in the joints of the masonry. Depending on the strength required and resistance to weathering, the proportions of the mortar are decided.

#### 3.1.3 Common Building Stones of India

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Stone</th>
<th>Classification</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basalt and trap</td>
<td>Igneous</td>
<td>Road metal, for rubble masonry, foundation work etc.</td>
</tr>
<tr>
<td>2</td>
<td>Chalk</td>
<td>Sedimentary</td>
<td>Preparing glaziers putty, coloring material in Manufacture of Portland cement.</td>
</tr>
<tr>
<td>3</td>
<td>Gneiss</td>
<td>Metamorphic</td>
<td>Street paving, rough stone masonry work etc.</td>
</tr>
<tr>
<td>4</td>
<td>Granite</td>
<td>Igneous</td>
<td>Steps, sills, facing work, walls, bridge piers, columns, Road metal, ballast, etc. Unsuitable for carving.</td>
</tr>
<tr>
<td>5</td>
<td>Kankar</td>
<td>Sedimentary</td>
<td>Road metal, manufacture of hydraulic lime etc.</td>
</tr>
<tr>
<td>6</td>
<td>Laterite</td>
<td>Metamorphic</td>
<td>Building stone, road metal, rough stone masonry etc.</td>
</tr>
<tr>
<td>7</td>
<td>Limestone</td>
<td>Sedimentary</td>
<td>Floors, steps, walls, road metal, etc.</td>
</tr>
<tr>
<td>8</td>
<td>Marble</td>
<td>Metamorphic</td>
<td>Flooring, facing work, columns, steps, ornamental work etc.</td>
</tr>
</tbody>
</table>
3.1.4 Some Definitions in stone masonry

Natural bed: The plane along which the stone can be split easily is the natural bed of stone. In stone masonry the natural bed should be perpendicular to the direction of the pressure.

Sill: The bottom surface of a door or window opening is known as sill.

Course: A layer of stones or bricks is known as a course.

Coping: To protect the wall from rain water, a course of stone is provided at the top of the wall. Such a course of stone is known as coping.

Plinth: The height of ground floor level above ground level is known as plinth.

Spalls: The chips of stones used to fill the empty faces in stone masonry are known as spalls. These are used in dry masonry.

Quoins: The external corners or angles of a wall surface are known as the quoins.

Jambs: The sides of the opening such as doors, windows are known as jambs.

Face: The surface of a wall exposed to weather is known as facing. It is the external side of the wall.

Back: The inner surface of the wall which is not exposed to weather is known as back.

3.1.5 Classification of Stone Masonry

Stone masonry is broadly classified as Rubble masonry and Ashlar masonry.

Rubble masonry is further classified as

- Coursed rubble masonry
- Uncoursed rubble masonry
• Random rubble masonry
• Dry rubble masonry
• Polygonal masonry
• Flint masonry
• Ashlar masonry is further classified as
  • Ashlar fine
  • Ashlar rough tooled
  • Ashlar rock or quarry faced
  • Ashlar chamfered
  • Ashlar block in course.

3.1.6 Rubble and Ashlar masonry

**Rubble masonry**: In rubble masonry, the stones of irregular sizes are used. Rubble masonry is further classified as Coursed rubble masonry and uncoursed rubble masonry depending on the size of the stones used.

**Coursed rubble masonry**: In coursed rubble masonry, stones of particular courses are of equal height. The heights of the stone vary from 50 mm to 200 mm. This type of buildings are used for public buildings, residential buildings etc. Depending on the heights of each course and the thickness of mortar joints, course rubble masonry is further classified as course rubble masonry I sort, course rubble masonry II sort and course rubble masonry III sort.

**Un cours ed rubble masonry**: In this type of masonry, the courses are not maintained regularly. The larger stones are laid first and the spaces between them are filled by means of spalls. The wall is brought to level every 300 to 500 mm. This type of rubble masonry is cheaper. It is used for the construction of godowns, compound walls, garages, labour quarters etc.

Fig 3.1 (a) Coursed rubble masonry  Fig 3.1 (b) Random rubble masonry
**Random rubble masonry** : In this type of masonry, the stones are selected at random. Their size and shape is not considered. Skill is required to make this masonry structurally stable. This type of masonry is used for construction of foundations, compound walls, godowns etc.

**Ashlar masonry** : In this type of masonry square or rectangular blocks of stones are used. The height of stones vary from 250 to 300 mm.

**Following are the different types of ashlar masonry**

**Ashlar fine masonry** : In this type of ashlar masonry, the beds and sides are finely dressed with a chisel. The stones are arranged in proper bond. The thickness of the mortar joint does not exceed 3 mm. This type of joint gives perfectly smooth appearance. It is very costly construction.

**Ashlar rough tooled masonry** : In this type of ashlar masonry, the beds and sides are finely dressed with a chisel. But the face is roughly dressed by means of tools such as hammer. The thickness of the mortar joint does not exceed 6 mm.

**Ashlar rock or quarry faced masonry** : In this type of ashlar masonry, a strip of 25 mm wide is provided around the perimeter of every stone, by means of a chisel. The remaining portion of the stone is left as it is received from the quarry. This type of construction gives massive appearance.

**Ashlar chamfered masonry** : In this type of ashlar masonry, the strip of 25 mm wide is provided as in ashlar rock or quarry faced. The strip is beveled or chamfered at an angle of 45 degrees with a chisel for a depth of 25 mm. Another strip 12 mm wide is provided on the remaining exposed face of the stone. The surface inside this strip is left as it is received from the quarry. A neat appearance of grooved joint is obtained with this type of construction.

![Fig 3.2 Ashlar fine masonry](image)
3.1.7 Table: Tools For Stone Masonry

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Name of the tool</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Trowel</td>
<td>To lift and to spread mortar</td>
</tr>
<tr>
<td>2.</td>
<td>Spirit level</td>
<td>To check the horizontality of the work</td>
</tr>
<tr>
<td>3.</td>
<td>Plumb rule and bob</td>
<td>To check the verticality of the work</td>
</tr>
<tr>
<td>4.</td>
<td>Square</td>
<td>To set right angles</td>
</tr>
<tr>
<td>5.</td>
<td>Line and pins</td>
<td>To maintain the alignment</td>
</tr>
<tr>
<td>6.</td>
<td>Spall hammer</td>
<td>To dress the stones in the quarry</td>
</tr>
<tr>
<td>7.</td>
<td>Mash hammer and Waller hammer</td>
<td>To dress the stones</td>
</tr>
<tr>
<td>8.</td>
<td>Axe</td>
<td>To dress roughly and to split the stones in the quarry</td>
</tr>
<tr>
<td>9.</td>
<td>Pitching tool</td>
<td>To make the stones of required size</td>
</tr>
<tr>
<td>10.</td>
<td>Jumper</td>
<td>To bore holes for blasting purposes in a quarry</td>
</tr>
</tbody>
</table>

3.1.8 Joints in stone masonry

1. **Butt or square joint**: In this type of joint, the square surface of one stone is placed against that of another. This is the most common joint. It is extensively used for ordinary work.

2. **Rebated or lapped joint**: In this type of joint, the rebates are provided to prevent the movement of stones. This type of joint is used for arch work, coping on gables, etc.

3. **Tongued and grooved joint**: In this type of joint, a projection is kept on one stone and a corresponding sinking is provided on the other stone. This type of joints is provided for the ends of ashlar masonry.

4. **Tabled joint**: In this type of joint, a projection is formed on the bed of one stone and sinking is provided at the stone above it. The depth of projection is about 40 mm and the width of projection is about one third of the width of the stone. This type of joint is used where the lateral pressure is heavy.

5. **Rusticated joint**: Sometimes the margins or edges of stones used for plinth, quoin, etc are sunk below the general level. Such types of joint are known as rusticated joint.
Fig 3.3
Fig 3.4

- Ordinary pick
- Scabbling pick
- Serrated pick
- Crow bar
- Pitching tool
- Punch
- Point
- Gauge
- Broad tool
- Boiler
- Wood handled chisel
- Claw chisel
- Tooth chisel
- Jumper
- Drag
- Gad
- Hand saw
- Cross cut saw
- Frame saw
- Bevel
6. **Plugged joint**: In this type of joint dovetail shaped mortises are provided in the sides of adjacent joints. After the stones are placed in position molten lead or cement grout is poured in the joint. This joint is used for copings, cornices etc.

7. **Dowelled joint**: In this type of joint, a hole is cut into each stone. Dowels which are pieces of hard stone are inserted into that hole and secured with cement. This joint ensures stability of stone against the displacement.

**Points to be observed while supervising the stone masonry**

Following points are to be carefully observed while supervising the stone masonry

1. The stones to be used for stone masonry should confirm with the requirements of the specification of the work.
2. The stones should be well watered before use. Then they will not absorb water from the mortar.
3. All the stones should be laid on their natural bed.
4. The dressing of the stone surfaces should be carried out as per the requirements of the specification of the work.
5. Bond stones should be provided at an interval of 1 metre.
6. The formation of continuous vertical joints should be avoided.
7. As far as possible, the stone work should be raised uniformly. But when this is not possible, steps or tooting or recess is provided.
8. In stone work, small pieces or broken stones should not be used.
9. The double scaffolding should be provided to carry out the stonework at the higher level.
10. The stonework should be carried out as per line and level. Line is checked by means of plumb bob and level by spirit level.
11. After construction, the stone work should be well watered for a period of about two weeks.
Fig 3.6

Concave joint  V-Joint  Weeping motor joint  Beaded motor joint

Raked motor joint  Flush motor joint  Stuck motor joint  Weathered joint

Properly prepared joint  Improperly prepared joint
3.2. Brick Masonry

Introduction

Bricks are rectangular blocks of uniform size. They can be properly arranged and bonded together. Further lifting devices are not required as they are light in weight. Hence brick masonry is extensively used in the construction of walls, arches, water supply and sanitation etc.

3.2.1. Definition of brick masonry

The systematic arrangement of bricks and binding them together with mortar to form a homogeneous mass is known as brick masonry.

Some definitions

Stretcher: The bricks laid with its length parallel to the face of the wall is known as a stretcher

Header: The brick laid with its breadth or width parallel to the face of the wall is known as a header.

Bed: The lower surface of the brick when it is laid flat is known as a bed.

Closer: A piece of the brick which is used to close up the bond at the end of the brick is known as a closer. It helps in preventing the formation of continuous vertical joint.

Queen closer: Queen closer is obtained by cutting the brick longitudinally into two equal parts. A queen closer is generally provided near the quoin header.
**King closer**: King closer is obtained by cutting a triangular portion of the brick. The centre of the header is joined to the centre of the stretcher to cut the triangular piece. A king closer is used near the doors and window openings.

**Bat**: This is a piece of the brick usually considered in relation to the length of a brick. If the piece of the brick is of one fourth length, it is a quarter brick bat. Similarly, half brick bat and three fourth brick bats.

**Frog**: A depression formed on the top surface of the brick at its centre is known as a frog. The depression formed is 10 mm to 20 mm.
3.2.2 Types of brick masonry

The brick masonry is classified into various types, according to the type of mortar, quality of bricks and thickness of mortar joints.

1. **Brick work in mud**: In this type of brick work, the mud is used to fill up the joints. The mud is prepared by intimately mixing sand with clay. The thickness of the mortar joint is 12 mm. This type of brick work is adopted in the case of cheap construction. The maximum height of the wall should not exceed 4.0 m.

2. **Brick work in cement mortar or lime mortar First class**: In this type of brick work, cement or lime mortar is used. The bricks are table moulded, and they are of standard shape and size, and they are burnt in kilns. The surface and the edges of the brick are sharp, square and straight. The thickness of the joint does not exceed 10 mm.

3. **Brick work in cement mortar or lime mortar second class**: The bricks to be used in this type of brick work are moulded on ground and they are burnt in kilns. The surface of the brick is some what rough and the shape is slightly irregular. The edges of the bricks are not sharp and uniform. The thickness of the mortar joint is 12 mm. These bricks are commonly used when they will be covered with plastering.

4. **Brick work in cement mortar or lime mortar third class**: The bricks used are ground moulded and they are burnt in clamps. The bricks are not hard and they have rough surfaces with irregular and distorted edges. This type of brick work is used for unimportant and temporary works.

3.2.3 Various types of bonds in brick work

The following are the various types of bonds in brick work.

1. Stretcher bond
2. Header bond
3. English bond
4. Flemish bond
5. Garden wall bond
6. Raking bond
7. Dutch bond
8. Bricks on edge bond
Out of all these types of bonds, the load bearing walls are constructed in English bond and Flemish bond only. The stretcher bond consists of bricks arranged in stretcher courses while the header bond consists of bricks arranged in header courses. The English bond is considered as the strongest. The Flemish bond gives better appearance. The garden wall bond is confined to garden walls, compound walls, etc. The raking bond consists of bricks placed in inclined direction. The Dutch bond is the modified form of English bond. Here the quoin of the stretcher is a three fourth brick bat. IN bricks on edge bond, the bricks are laid on its edge instead of bricks on bed as in other types of bonds.

**English bond:** This type of bond is generally used in practice. It is considered as the strongest bond in the brick work. The following are the features of an English bond.

i. The English bond consists of alternate courses of headers and stretchers.

ii. The queen closer is placed adjacent to the quoin header.

iii. Each alternate header is placed centrally over a stretcher.

iv. In the case of even multiples of half brick walls, both the face and back consists of either headers or stretchers.

v. In the case of odd multiples of half brick walls, if the face is a header, the back is a stretcher and vice versa.

vi. The continuous vertical joints are not formed except at the ends.

The number of joints in the header course is nearly double than that of stretcher course.

---

**Fig 3.11 Elevation**
Plan of stretcher course
One brick wall English bond

Plan of header course
One brick wall English bond

Plan of stretcher course

Plan of header course

Back

Face

Back

Face

Fig 3.12
**Flemish bond**: In Flemish bond there are alternate headers and stretchers in a course. It creates better appearance than English bond. The following are the main features of the Flemish bond.

i. In every course, headers and stretchers are placed alternate to each other.

ii. The queen closer adjoins quoin header.

iii. Each header is centrally placed over a stretcher.

iv. The bricks in the same course do not break joints with each other. The joints are straight.

v. In this bond short continuous vertical joints are formed.
3.2.4 Defects in brick masonry

The brick masonry may develop defects mainly due to the following four reasons.

1. Corrosion of embedded fixtures
2. Crystallization of salts from bricks
3. Shrinkage on drying
4. Sulphate attack

1. **Corrosion of embedded fixtures**: The iron or steel fixtures like pipes, holdfasts etc, which are embedded in brick masonry may get corroded in presence of dampness. The metal expands in volume due to corrosion. It leads to the cracking of brick work. If a dense mortar of a cover of 15 mm to 25 mm is provided, this defect can be prevented.

2. **Crystallization of salts from bricks**: When bricks containing excessive soluble salts are used in masonry work, this defect develops. When such bricks come in contact with water, the soluble salts are dissolved and fine whitish crystals are seen on the surface of brick work. This phenomenon is known as efflorescence. The remedy for this defect is brushing and washing the effected surface.
3. Shrinkage on drying: The brick work normally swells with the absorption of water and shrinks when the water evaporates. During the process of shrinkage, cracks are developed in the masonry. This defect can be prevented by using good quality of bricks.

4. Sulphate attack: The sulphate salts present in brick, react with alumina in the case of cement mortar. Similarly it will react with hydraulic lime in the case of lime mortar. This results in increase in volume of the mortar. It leads to chipping and spilling of bricks. The entry of water into the brick work should be checked to prevent this defect.

3.2.5. Structures in brick masonry

The various structures that can be constructed in brick work are: Brick Footings, Piers, Buttresses, Retaining walls, Thresholds, Window sills, Jambs, Corbels, Copings, Circular Brick work, Fire Places and Cavity walls.

1. Brick footings: If the walls and piers are constructed in brick work, then the footings shall also be constructed in brick work.

2. Piers: The intermediate or end supports of for beam or trusses are known as piers. If they are constructed in brick work they are known as brick pillars or brick columns.

3. Buttresses: Buttresses are the sloping piers to work as lateral supports of the wall. They are provided to support inclined roofs, jack arches etc.
4. Retaining walls: A retaining wall is constructed to retain the artificial filling of earth.

5. Thresholds: The bottom of opening of all external doors and entrances from verandahs are to be provided with one or more steps. This arrangement is known as threshold.
6. **Window sill**: In order to give a suitable finish to the window opening and to protect the external below such opening, window sills are provided. Window is placed over the window sill.

7. **Jambs**: The vertical sides of the openings, which are left in the walls to receive doors, windows etc, are known as jambs.

![Fig 3.18 Jambs](image)

8. **Corbel**: A brick corbel is constructed to support floor beams, girders, jack arches etc, as shown.

![Fig 3.19 Corbel](image)

9. **Copings**: To throw off water from the structure, coping is provided at the top of the structure.

![Fig 3.20 Copings](image)
10. **Circular brick work**: When brick work is to be done on a curvature, as in the case of chimneys, soak pits, flues etc, specially moulded bricks are used.

11. **Fire places and flues**: In buildings constructed in the region of cold weather, fire places are constructed in other rooms besides kitchen. The passage for carrying smoke or hot air is known as a flue or a chimney.

12. **Cavity wall**: Two separate walls with a cavity or gap between them is known as a cavity wall. Cavity wall is provided to prevent dampness, heat insulation, sound insulation etc.

### 3.2.6. Tools used in brick masonry

1. **Trowel**: A trowel is used to lift and spread mortar.

2. **Spirit level**: A spirit level is used to check the horizontality of the work.

3. **Plumb bob**: A plumb bob is used to check the verticality of the work.
4. **Square**: A square is used to set right angles or setting lines in mutually perpendicular directions.

5. **Lines and pins**: Lines and pins are used to maintain the alignment.

6. **Club hammers**: A club hammer is used to strike the narrow headed chisels.
7. **Bevel**: A bevel is used to set out angles

![Bevel Image](image)

**Fig 3.27 Bevel**

8. **Straight edge**: A straight edge is a piece of wood one metre long and of section 80 mm x 15 mm. It is used for checking the alignment of the work.

### 3.2.7 Points to be remembered in the supervision of brick masonry

The following points are to be carefully observed while supervising brick masonry.

1. The bricks to be used should confirm with the requirements of the specification of the work.
2. The bricks should be immersed in water before they are used.
3. The bricks should be properly laid on their beds.
4. The mortar should cover the beds as well as the sides of the bricks.
5. The bricks should be carried out in proper bond.
6. The brick work and mortar should comply with the specifications of the work.
7. As far as possible the brick masonry should be raised uniformly.
8. For cross wall or at the end of days work, steps or sothings are provided.
9. In brick masonry, bats less than half bricks shall not be used.
10. The brick masonry should be carried out as per line and level.
11. After construction, the brick masonry should be well watered for a period of two to three weeks.
Summary

- Materials used in stone masonry: Stone and mortar
- Classification of stone masonry: Rubble masonry and Ashlar masonry
- Classification of Rubble masonry: Coursed Rubble masonry, uncoursed rubble masonry, random
- Rubble masonry, polygonal masonry, flint masonry and dry masonry
- Classification of Ashlar masonry: Ashlar fine, ashlar rough tooled, ashlar rock or quarry faced,
- Ashlar chamfered and ashlar block in course.
- Tools used in stone masonry: Trowel, Spirit level, Plumb rule and bob, Square, Line and pins,
- Spall hammer, Mash hammer and Wallet hammer, Axe, Pitching tool, Jumper
- Joints used in stone masonry: Butt joint, Rebated joint, Tongued and grooved joint, Tabled joint,
- Rusticated joint, Plugged joint and Dovetailed joint.
- **Types of brick masonry**: Brick work in mud, Brick work in cement or lime mortar first class, Brickwork in cement or lime mortar second class, Brick work in cement or lime mortar third class.
- **Various types of bonds in brick work**: Header bond, Stretcher bond, English bond, Flemish bond, Garden wall bond, Raking bond, Dutch bond and Bricks on edge bond.
- **Defects in brick masonry**: Corrosion of embedded structures, Crystallization of salts from bricks, Shrinkage on drying, Sulphate attack.
• **Structures in brick masonry**: Brick footings, Piers, Buttresses, Retaining walls, Thresholds, Windows and sills, Jambs, Corbels, Copings, Circular brick works, Fire places and Cavity walls.

• **Tools used in brick masonry**: Trowel, Spirit level, Plumb bob, Square, Line and pins, Club hammer, Bevel and Straight edge.

### Short Answer Type Questions

1. Define stone masonry
2. What are the materials used in stone masonry.
3. What is Rubble masonry.
4. Define Ashlar masonry.
5. List out the classification of rubble masonry
6. List out the classification of Ashlar masonry.
7. What is a bond stone?
8. In stone masonry, at what distance are bond stones provided.
9. List out the various tools used in stone masonry
10. What are the various types of joints used in stone masonry?
11. Define brick masonry.
12. Define the following: Header, Stretcher, Queen closer, King closer, Frog, Bat.
13. List out the various types of brick masonry
14. List out the various types of bonds in brick masonry.
15. What is an english bond and a Flemish bond?
16. What is the basic difference between an english bond and a Flemish bond?
17. What are the various defects in brick masonry?
18. Where do you provide a queen closer and a king closer.
19. Mention the various types of structures in brick masonry.
20. List out the various tools in brick masonry.
21. What are the tools used for checking the horizontality and verticality of brick masonry?

**Long Answer Type Questions**

1. What are the materials required for stone masonry?
2. How is stone masonry classified?
3. Describe the different forms of rubble masonry
4. Describe the different forms of ashlar masonry.
5. Describe the various types of joints used to secure the stones with each other.
6. What are the points to be observed while supervising the stone masonry?
7. What are the various types of brick masonry?
8. What are the characteristics of an English bond?
9. Draw a neat sketch of the elevation of an English bond.
10. Draw a neat sketch of the plan of an odd course and even course of an English bond.
11. What are the characteristic of a Flemish bond?
12. Draw a neat sketch of an elevation of a Flemish bond.
13. Draw a neat sketch of the plan of an odd course and even course of a Flemish bond.
14. What are the various defects in brick masonry.
15. What are the points to be observed while supervising brick masonry?
4.0 Introduction

Openings are provided in the structure for providing access to the users of the structure, and for the purpose of providing daylight, vision and ventilation. If the opening is provided for providing access to the users, it is a door. If the access is provided for the purpose of providing daylight, air and ventilation, it is a window. Ventilators are provided above the top of the windows for ventilation.
4.1 Doors and Windows

4.1.2 General terms used in Doors and Windows

1. **Frame**: A group of members which form support for a door or a window is known as a frame.

2. **Style**: The outside vertical member of a door or a window is known as style.

3. **Head**: The top or uppermost horizontal part of a frame is known as the head.

4. **Sill**: The lowermost or bottom horizontal part of a window frame is known as the sill.

5. **Top rail**: This is the top most horizontal member of the shutter.

6. **Lock rail**: This is the middle horizontal member of the shutter where the locking arrangement is provided.

7. **Bottom rail**: This is the lowermost horizontal member of the shutter.

8. **Panel**: This is the area of shutter enclosed between the adjacent rails.

9. **Hold fast**: A mild steel flat bar of cross section 30 mm x 60 mm and length 200 mm attached to the frame is known as a hold fast. Two or three hold fasts are attached on each side of the frame to keep it in position.
10. **Horn**: The horizontal projection of the head or sill beyond the face of the frame is known as a horn. It helps in fixing the frame on the wall opening.

11. **Shutter**: The entire assembly of styles, panels and rails is known as the shutter.

12. **Mullion**: This is the vertical member at the centre which subdivides the door or window opening vertically.

13. **Jamb**: The vertical face of the opening which supports the frame of a door and window is known as the jamb.

### 4.1.3 Types of Doors

Depending upon the type of materials and the method of construction the various types of doors are as follows.

1. Battened, ledged and braced door
2. Panelled door
3. Glazed or sash door
4. Flush door
5. Louvered door
6. Collapsible door
7. Revolving door
8. Rolling shutter
9. Sliding door
10. Swing door

**1. Battened Ledged and braced door**: Battened, Ledged and braced door is formed by joining vertical members known as battens, horizontal members known as ledges and diagonal members known as braces. These members are 100 mm to 200 mm wide and 20 mm to 30 mm thick. They are hanged to the supports with a T-Hinge. These doors are used for the purpose of privacy, but they are not strong for security.
2. Panelled door: A paneled door consists of framework of vertical members called styles and horizontal members called rails. A framework of panels is formed and planks of 20 mm thickness are fitted into these panels. The styles and rails are 100 mm thick in width and 30 mm in thickness. The lock rail is 150 mm wide. The length of the members is decided as per the design. The framework is formed by mortice and tenon joint. This type of door reduces the tendency to shrinkage. They present a decent appearance. They are the most widely used doors.
3. Glazed or sash door: In order to admit more light in addition to that coming from the windows, glass doors are used. If the full door is covered with glass it is fully glazed door. If the door is partly paneled and partly glazed, it is known as paneled and glazed door. If the glass is enclosed in a framework of sash bars it is glazed and sash door.

The glazed or sash doors are useful for hospitals, offices, libraries, show rooms, banks, shopping units etc.
4. **Flush doors**: A flush door consists of a framework of rails and styles. It is covered with plywood or hard wood. There are two varieties of flush doors – Framed flush door and laminated flush door.

**Framed flush door**: In a framed flush door, a frame is made of styles and rails. Horizontal ribs and vertical ribs are inserted into this frame. Plywood is attached to this framework. Lock block and hinge block is provided to this door. These doors are light in weight, but they are not in existence at present.

**Laminated flush door**: It consists of a frame formed by styles, rails and laminated core. The plywood sheet of thickness 6 mm are glued to this laminated core on either side. The thickness of this flush door is 25mm to 30 mm.

Instead of framed and laminated flush door, now a days flush door is prepared with a single plywood sheet of 20 mm thickness. Attractive colour, sunmica sheets are glued to this plywood.

The flush doors are economical, easy to clean, better in appearance, reasonably strong, moisture and termite proof. They are widely used in residential buildings.

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**Fig 4.8**
5. **Louvered doors**: In this types of doors, the shutters are provided with inclined members known as louvers. The louvers are arranged at an inclination, such that horizontal vision is obstructed. However light and air passes through the gap between the louvers. The louvers are either fixed or movable. These doors allow free passage of air when closed and at the same time, maintain sufficient privacy. They are used for sanitary blocks.

6. **Collapsible steel doors**: A collapsible steel door consists of mild steel frame. Two vertical pieces of mild steel channels are joined together with a hollow portion inside. Such pieces are spaced at 120 mm centre to centre and are joined by cross pieces. Rollers are mounted at the top and bottom of the vertical pieces. The door can be opened or closed by slightly pushing the handles. It is used at educational institutions and public places. Light and ventilation are provided even when the doors are closed or opened.

7. **Revolving door**: A revolving door essentially consists of a centrally placed mullion or a pivot. The door rotates about the pivot. Leaves or shutters are attached to this pivot.

   A revolving door simultaneously provides entrance on one side and exit on the other end. It is used at places where there is heavy traffic and also in air conditioned buildings.

8. **Rolling shutter**: A rolling shutter consists of a frame, a drum and thin sheets of iron or steel. A horizontal shaft and springs are provided in the drum at the top. By pushing the shutter it revolves around the drum. The door can be opened or closed.
These doors are sufficiently strong. They are used for garages, shops, godowns, factory buildings etc.

![Fig 4.10 Revolving Door](image)

4.1.4 Preparation and uses of various types of windows

Types of windows

1. Casement window
2. Pivoted windows
3. Sliding windows
4. Louvered windows
5. Sash or glazed windows
6. Corner windows
7. Dormer windows
8. Bay windows
9. Clerestorey windows
10. Sky lantern windows

1. Casement windows: These are the windows which open like doors. Similar to paneled door, it consists of a frame of styles and rails. For wooden windows planks are inserted into the panels formed by the styles and rails. In the case of glazed windows, a frame of horizontal and vertical sash bars are formed. Glass is inserted into this frame.
2. **Pivoted window**: In this type of windows, the shutters are allowed to swing around the pivots. The windows may be pivoted horizontally or vertically. The pivoted windows are easy to clean. They admit more light.

**Fig 4.11 Rolling Shutter**

**Fig 4.12 Casement window**
3. **Sliding windows**: These windows are similar to sliding doors. The shutters move on the roller bearings, either horizontally or vertically. Such windows are provided in trains, buses, bank counters, shops etc.

![Frame Pivot Shutter Frame Pivot Shutter Frame Pivot Shutter Frame Pivot Shutter Frame Pivot Shutter](image)

**Fig 4.13**

4. **Louvered windows**: These type of windows are similar to louvered doors. Louvers are provided to the framework of windows. The framework consists of top rail, bottom rail and two styles. Louvers are usually inclined at 45 degrees to this framework. They allow free passage of air when closed. At the same time they maintain privacy.

5. **Sash or glazed windows**: These are fully glazed casement windows. The sashes are rebated to receive glass panels. The glass is secured in position either by putty or by small fillets.

6. **Corner windows**: These windows are placed at the corner of a room. They have two faces in two perpendicular directions. There is entry of light and air from both the perpendicular directions. The elevation of the building is improved.

![Wall Frame Room Shutter Glazing Wall Frame](image)

**Fig 4.14 Corner window**
7. **Dormer windows**: These windows are provided on the sloping roof. The main purpose of dormer window is to admit light and air to rooms below sloping roof.

![Dormer window](image)

**Fig 4.15 Dormer windows**

8. **Bay windows**: These windows project outside the external walls of a room. The projection may be square, splayed, circular, polygonal or any shape. The projection may start from floor level or sill level. These windows admit more light, increase open area, provide ventilation and improve the appearance of the building.

![Bay windows](image)

**Fig 4.16 Bay windows**

9. **Clerestorey windows**: These windows are provided near the top of main roof. Pivoted windows are used for this purpose. These windows provide ventilation to the inside of the room as the front portion of the room is blocked by the verandah. They also improve the appearance of the building.
10. **Sky lantern windows**: In sloping roofs if the light coming from the external windows is insufficient, sky lantern windows are provided. The common rafters are suitably trimmed and the sky light is erected on the curb frame. Glass panels are fixed to this curb frame.

4.1.5 **Fixtures and fastenings for doors and windows**

The various fixtures and fastenings for doors and windows are hinges for fixing doors and window shutters to their respective frames. The various types of hinges are back flap hinge, butt hinge, garnet hinge, counter flap hinge,
parliamentary hinge, raising butt hinge and strap hinge. Out of these, butt hinges are most commonly used. Garnet hinge is used for ledged and braced door. Parliamentary hinges are used to keep the door away from the wall. Pin hinge is used to hang heavy doors. Rising butt hinge is used to raise the door while opening it and to close it automatically.

Bolts are used for closing the doors. Aldrop bolt is used on external doors. Barrel bolt is used to fix back faces of the doors. Espagnolette bolt is used for high doors. Flush bolt is used to keep the bolt flush with the face of the door. Latch is used to secure the doors. Similar to barrel bolt, tower bolt is used to fix back faces of the door. Two or more tower bolts are required to fix the back faces of the door.

Locks are used to lock the doors. Cupboard lock is used to secure and lock doors of minor importance like cup boards. Hook and eye is used to keep window in open position. Mortise lock is used at the edge of the door to secure the door in mortise. Pad lock is used for securing doors when aldrop bolts or hasp and stable bolts are used. Peg stays are used for steel windows. The width of the opening can be adjusted by the holes in the peg stay.

Handles are used for moving the doors. Bow handle is used to open the door. Lever handle works with the lever and door closes automatically when handle is released. Wardrobe handle is elliptical in shape.

Fig 4.19
4.2 Ventilators

The ventilators are windows of small heights and they are generally fixed at the top of the doors and windows. If the ventilators are permanently fixed at a particular position, they are fixed windows. They may be provided with grills or mosquito proofing for security.

If the shutters are provided to the ventilators, so that they can be rotated or moved about a pivot, they are known as swing ventilator.
Summary

1. An opening for providing access to users is a door.

2. An opening for providing day light, air and ventilation is known as ventilator.

3. The component parts used in doors and windows are frame, style, head, sill, top rail, lock rail, bottom rail, panel, hold fast, horn, shutter, mullion and jamb.

4. The various types of doors are battened, ledged and braced door, paneled door, glazed or sash door, flush door, louvered door, collapsible door, revolving door, rolling shutter, sliding door and swing door.

5. The various types of windows are casement window, pivoted window, sliding window, louvered window, sash or glazed windows, corner window, dormer window, bay window, clerestorey window, sky lantern window.

6. The various fixtures and fastenings to doors and windows are hinges, bolts, locks and handles.

7. Ventilators are provided above the doors and window openings. There are fixed ventilators and swinging ventilators.

Short Answer Type Questions

1. What is an opening?

2. Define the following terms frame, style, head, sill, rail, panel, horn, shutter, mullion.

3. List out the various types of doors.

4. Where do you provide a louvered door.

5. What type of door is provided for air conditioned buildings and for controlling heavy traffic?

6. List out the various types of windows.

7. Where do you provide sliding windows.

8. What is the advantage of a bay window?

9. List out the various types of fixtures and fastenings for doors and windows.
10. What are the various types of ventilators?

**Long Answer Type Questions**

1. What are the various types of doors? Describe any two.

2. Draw a neat sketch of a paneled door. Describe any four parts.

3. What are the various types of windows? Describe any two.

**O.I.T. Questions**

1. Calculate the quantity of wood work required for a paneled door.

2. Calculate the quantity of wood and glass required for glazed and casement window.

3. Identify the different types of wood, glass and various accessories required for doors and Windows.
Structure

5.0 Introduction
5.1 Types of Lintels
5.2 Sunshade

Learning Objectives
After completion of this unit, the student should be able to understand

• The necessity of lintel, various types of lintel,
• Definition of the sunshade,
• Types of ventilators.

Introduction

To construct above doors and window openings, arches and lintels are used. Even from stone age, different materials are used to support the construction above these openings. Various types of arches are also used to span over these openings. Due to its ease in construction lintels are preferred. At present lintels, especially R.C.C. lintels are widely used in construction.

Definition: A lintel is a horizontal member which is placed across an opening to support the portion of the structure above it.
Lintels are simple and easy to construct. The ends of the lintels are built into the masonry. Thus the load carried by the lintels is transferred to the masonry.

The distance upto which the lintel is inserted into the supporting wall is known as the bearing. The bearing should be the minimum of the following three considerations.

(i) 100 mm
(ii) Height of lintel
(iii) One tenth to one twelfth of the span of lintel.

5.1 Types of lintels

Depending on the type of materials used in the construction the various types of lintels are as follows.

1. Wooden lintel
2. Stone lintel
3. Brick lintel
4. Steel lintel
5. Reinforced cement concrete lintels

**Wooden lintels or timber lintels**: The pieces or a piece of timber placed across an opening are known as wooden or timber lintels. Usually a single piece of timber is preferred. If it is not possible three timber pieces are bolted together to serve as a lintel.
Advantages
1. The wooden lintel helps in securing the heads of the frames of the doors and windows in position.
2. These are light in weight.

Disadvantages
1. The wooden lintels are comparatively weak in strength.
2. The wooden lintels are liable to be destroyed by fire and are also liable to decay.
3. The wooden lintels are very costly.

Uses
The wooden lintels are used in hilly areas, where wood is easily available.

Stone lintels: These lintels consists of slabs of stones which are placed across the openings. The stone lintels may be formed by a single piece or more than one piece.

Advantages
1. It is easy to dress a stone.
2. It is possible to have architectural appearance.

Disadvantages
1. The stone possesses low tensile resistance.
2. The stone cracks when subjected to vibratory loads.
3. It is difficult to obtain stones of required depth.

Uses
The stone lintels is used at places where stone slabs are easily available. It can be used for slabs upto 1 m span.

Brick lintels: A brick lintel is constructed by placing the bricks on end or edge. A temporary wood support is necessary to construct a brick lintel. The brick lintel should have a depth of multiples of the thickness of the brick.
Advantages

1. A brick lintel is not subjected to decay and it has good resistance to fire.
2. It is easy to secure door and window frames to brick lintels.

Disadvantages

1. A brick lintel is not suitable for slab greater than 1 m span.
2. A brick lintel is heavy and adds to more load on the structure.

Uses

The brick lintels are used where bricks are easily available. It is used at places which are likely to be subjected to decay or fire.

Steel lintels: The steel lintels consist of steel angles or rolled steel joints. Steel angles are used for lesser loads while rolled steel joints are used for heavier loads. The ends of these steel members are embedded in concrete.
Advantages

1. The steel is strong in compression and tension.
2. Steel lintel occupies very little space.
3. They can be used for heavier loads.
4. The steel is durable.

Disadvantages

1. The steel lintels are easily effected by corrosion.
2. Skilled fabrication is necessary.
3. It is the most expensive lintel.

Uses

Steel lintels are used when sufficient space is not available to accommodate the rise of an arch. Further it is used at places where there is very heavy load.

Reinforced cement concrete (R.C.C.) lintels: These lintels are constructed with reinforced cement concrete. These lintels are most widely used and they have replaced all other lintels. They may be pre cast or they may be cast in situ. The usual mix of the concrete is of the proportion (1:2:4).

Reinforcement

Top: 2 Bars 6 mm dia
1 Bar 9 mm dia
Bottom: 2 Bars 9 mm dia

Rings 5 mm dia at 200 mm c/c

Reinforcement

Top: 2 Bars 6 mm dia
Bottom: 3 Bars 9 mm dia
1 1/2 Brick

Fig 5.4

Advantages

1. R.C.C. lintels are very strong in compression as well as tension.
2. They can be used for any length of the span.
3. They are durable.
4. They are fire resistant.
5. They are cheap.

Disadvantages

1. Temporary support is necessary.
2. It takes a lot of time to construct and cure the concrete.

Uses

It can be used at all places and it is practically only type of lintel in existence.

5.2. Sunshade

Definition of sunshade

Sunshade: The horizontal projection provided at the lintel level is known as a sunshade. Sunshades are provided to protect the building from the weathering effects like sun and rain. They are provided at doors and window openings. The usual width of the sunshade is 0.7 to 1.2 m. If the width of the sunshade is more than 2.0 m., it is a canopy. If the canopy is provided at the entrance of the building, it is a porch. Most of the sunshades are R.C.C. sunshades. Stone, steel and wooden sunshades can also be provided, but they are almost non existent at present. Pre-cast sunshades can also be used.

Beam Reinforcement

Top : 2 Bars 9 mm dia
Bottom : 3 Bars 12 mm dia
   2 straight and 1 Bent
Rings : 6 mm dia at 200 mm c/c
9 mm dia bars at 150 mm c/c
6 mm dia bars at 200 mm c/c
600 mm
Every third 9 mm dia bar bent as complete hook
200 mm
80 mm

Fig 5.5 R.C.C lintel and weather shed
Summary

Lintels are provided at the openings to support construction above the openings. The various types of lintels are wooden lintel, stone lintel, brick lintel, steel lintel and R.C.C. lintel. Sunshades are provided at the lintel level to protect the building from rain and sun.

Short Answer Type Questions

1. What is a lintel
2. List out the various types of lintels.
3. Define sunshade.
4. Where do you prefer a steel lintel?

Long Answer Type Questions

1. What are the various types of lintels? Write briefly any two types with advantages, disadvantages and uses.

O.J.T. Questions

1. Note down the size of the openings, thickness of the lintels and the size of the sunshades.
UNIT 6

Floors

Structure

6.0. Introduction

6.1. General terms involved in floors.

6.2. Various types of floors.

6.3. Materials required for cement concrete, terrazzo, mosaic and stone slab floors

6.4. Method of construction of cement concrete, mosaic, terrazzo and marble floors

Learning Objectives

After completion of this unit the student shall be able to understand the following General terms used in floors, preparation and uses of various types of floors, materials required for cement concrete, terrazo, mosaic and stones lab floors, methods of construction of various type sof floors.

6.0 Introduction

In order to sub-divide the portion between the plinth level and roof level solid constructions are carried out. These constructions are known as floors. The exposed top surfaces of the floors are known as floorings. If the building is multi storied, there will be floors at each stories of the building. Depending on the requirements different types of floorings can be selected.
6.1 General terms involved in floors

Floor: The sub-division of the building into plinth level, roof level and subsequent roof levels are known as floors. The floors are mentioned as ground floor, first floor, second floor etc.

Floorings: The exposed top surface of the floors are known as floorings. The floorings are indicated by the type of material and the workmanship used for the floor.

Plinth: The vertical height of the building from the ground level to the basement level is known as a plinth.

Sand filling: The height of the sand in foundation from ground level to the basement level is known as sand filling. The building is divided into rooms and each room is filled with sand from ground level to basement.

Sub base: Over the sand filling a layer of plain cement concrete (1:5:10) of 100 mm thickness is laid and compacted. This layer of concrete is known as sub base.

Base course: Over the sub base course, a layer of plain cement concrete (1:2:4) is laid and compacted. This layer is known as base course. The flooring with different materials is laid over this base course.

Finishing course: The final layer of the flooring with the respective flooring material is known as the finishing course.

6.2 Various types of floors

Basically the floors are classified as timber floors and composite floors. Floors composed of more than one material are composite floors. The various types of composite floors are Double flagstone floors, Filler joist floors, Jack arch floors, R.C.C. floors and hollow block and rib floors. Due to scarcity and high cost of timber, these floors are not in existence at present. The composite floors mentioned are constructed when Reinforced Cement Concrete is not in existence. They are not used in construction at present. The following floors are extensively used at present. Cement concrete flooring, Mosaic flooring, Terrazzo flooring and marble flooring depending on the type of flooring material used.

Factors affecting choice of flooring material: The following factors are to be carefully considered before selecting the material for flooring of a particular building.

1. Appearance: The flooring material should be of desired appearance. It should produce the color effect in conformity with the use of the building.
2. **Cleaning**: The flooring material should be such that it can be easily and effectively cleaned.

3. **Comfort**: The flooring material should be such that it gives desired comfort when it is put to use.

4. **Cost**: The cost of flooring material should be reasonable as compared to the utility of the building.

5. **Durability**: The flooring material should be durable. It should be strong enough to resist wear and tear, chemical action etc.

6. **Noise**: If silence is required, such flooring material which makes less noise should be preferred.

7. **Slipperiness**: The surface of the floor should not be too slippery. It is dangerous especially for old people, children and pregnant women.

### 6.3 Materials required for Cement concrete, Terrazzo, Mosaic, Marble and Stone slab floors.

**Cement concrete Flooring**: In cement concrete flooring, the thickness of the concrete layer is 40 mm. The proportions of this concrete consists of 1 part of cement, 2 parts of sand and 4 parts of coarse aggregate by volume. The size of the coarse aggregate varies from 20 mm to 6 mm. Over this layer of concrete, cement and sand mortar of proportion 1:3 is laid for a thickness of 20 mm. Over this cement sand layer, cement slurry is poured and it is smoothly finished with a trowel. It is cheap and it is used when cost factor is to be considered.

**Terrazzo flooring**: This is also a type of concrete flooring in which, marble chips are used as aggregates, marble powder as fine aggregate and cement. The proportion of marble chips and cement is 1:2 to 1:3. Any desired color may be obtained by using different colors of marble chips. If ordinary Portland cement is used only one color background of grey is obtained. If different color background is required, then white cement should be used instead of ordinary Portland cement. By mixing different color oxides with white cement we get the desired color of the floor.

After laying and watering for at least 7 days, polishing is carried out. First coat of polishing is done by coarse carborundum. Second coat is done by finely grained carborundum stone. Third coat is done by pumice stone. Final coat of polish is done by oxalic acid and wax. It can be used for residential buildings. As it is not as expensive as tiles and marbles it can be used be used for public places where cost factor is involved.
Mosaic flooring: Mosaic is a picture or pattern produced by fitting together small coloured pieces of stone. Precast tiles with marble chips at the top surface, known as mosaic tiles are used. In terrazzo flooring concrete layer is formed with marble chips where as in mosaic flooring mosaic tiles are laid. Polishing done after laying the tiles in position. As in terrazzo flooring, first coat of polishing is done by coarse carborundum stone, second coating with finely grained carborundum stone, third coating with pumice stone. Final coat of polish is applied with oxalic acid and wax. If glazed tiles are used, polishing is not required.

Marble and stone slab flooring: This type of flooring is used for superior work. It is especially used where cleanliness is required as in the case of operation theatres in hospitals, temples etc. Depending on the origin of its formation, different colors and different color shades are obtained. Even stone slabs of same geologic origin may have different color shades. Some stone slabs are polished and laid. But stone slabs of marble are laid, well watered for 7 days and they are polished. First coat of polishing is done with coarse carborundum, second coat with finely grained carborundum stone and third coat with pumice stone. Finally a coat of wax polish. At present seven coats of polishing is being done with coarse grained carborundum, fine grained carborundum and pumice stones.

6.4 Method of construction of Cement concrete, Mosaic, Terrazzo and Marble floors

Cement Concrete Flooring: Plain cement concrete of 1 part of cement, 2 parts of sand and 4 parts of coarse aggregate is laid for a thickness of 40 mm, over mass concrete (1:5:10). Over this layer a layer of cement sand mortar (1:3) is to be laid. To mark the gradient of the floor, cement sand mortar is initially laid at the corners of the room. The thickness of this layer is 20 mm. To maintain the gradient, more thickness is laid at the higher edges. A thin rope is placed on the opposite corners of the heap and the gradient is marked on the entire length by placing heaps of mortar under the thin rope. As per the gradient marked the entire area of floor is filled with the cement sand mortar. It is neatly trowelled as per the set gradient. Over this cement slurry is poured and it is neatly finished with a smooth trowel.

Mosaic Flooring: Pre-cast concrete tiles with mosaic chips at top surface, known as mosaic tiles are manufactured at the factory. They are available in standard sizes. These tiles are laid over a plain cement concrete of 20 mm thickness. Initially a border line is laid with plain colored tiles around the surface. The gradient is set while laying this border line. Cement mortar is placed below these tiles and the alignment of the surface is set. The remaining surfaced is filled
with tiles and cement mortar is placed below these tiles. After laying these tiles, they are well watered for 7 days. Carborandum stone is fixed to the polishing machine and it is run over the surface, leading to a first coat of polish. Similarly finely grained carborundum stone and pumice stones are placed under the machine and run over second and third coat of polishing. Finally oxalic acid and wax polishing is applied with the machine.

**Terrazzo Flooring:** Cement and marble chips are mixed to a proportion of 1:2 to 1:3. Enough water is added to this dry mixture and a paste is formed. As per the color back ground, different color chips, color acids and white cement are used. The mixture is laid over a sound and rough base. Initially a border strip is laid as per the required gradient. The remaining mixture is laid in between the border strip. This base is kept watered for 7 days. First coat of polishing is done by coarse carborundum stone. Second coat of polishing is done by finely grained carborundum stone and third coat of polishing with pumice stone. Polishing may be done with hand or with machine. Final coat of polish is applied with a wax.

**Marble Flooring:** Plain cement concrete (1:2:4) is laid over the sub base. To mark the alignment of the gradient, cement sand mortar heaps are placed at the corners of the room. Marble slabs are placed over these heaps and the gradient of the floor is checked. A thin rope is placed over these marble slabs. The remaining slabs are placed over the cement mortar as per the gradient set by this rope. After watering these marble slabs for 7 days, polishing is done. As in other types of flooring three coats of polishing and final coat of polishing with wax may be done. The present trend is to undertake seven to ten coats of polishing. The polishing coat with wax is avoided. This procedure of flooring may be continued for other stone slabs like cuddapah slabs and tiles. The methods of polishing is different for other types of slabs. Polishing is not required for tiles.

**Summary**

- The sub-division of the building into different levels is a floor while the exposed surface of the floors is known as the flooring.
- Sub- base is mass concrete (1:5:10) of 100 mm thickness.
- Base course is plain cement concrete (1:2:4) of 20 mm thickness.
- The factors affecting the choice of flooring material are appearance, cleaning, comfort, cost, durability noise and slipperiness.
- The various types of floorings are cement concrete flooring, mosaic flooring, terrazzo, marble and stone slab floors.
Short Answer Type Questions

1. Define floors and flooring.
2. List out the various types of floors.
3. What are the materials used in cement concrete flooring?
4. What are the materials used in terrazzo flooring?
5. Mention the various types of stones used in polishing the floors.
6. What are the factors affecting the choice of flooring material?

Long Answer Type Questions

1. What are the factors to be considered in deciding the choice of flooring material?
2. Describe the materials required for terrazzo flooring.
3. Write briefly the procedure of construction of cement concrete flooring.
4. Write briefly the procedure of construction marble floors.
5. Write short notes on mosaic flooring.
6. Write short notes on stone slab flooring.

OJT Questions

Identify the different floors used at different places.
UNIT 7

Roofs

Structure

7.0 Introduction

7.1 Definition of roofs and the concept of roofs.

7.2 Classification of roofs, various types of pitched roofs, king post truss and queen post truss.

7.3 Steel trusses – various parts of steel truss, panels for different spans.

7.4 Roof covering material for pitched roofs, flat roof and R.C.C. roof.

7.5 Tools required to fix AC sheet, G.I. sheet and roof covering.

7.6 Methods required for fixing of AC sheet.

7.7 General requirements of roof.

7.8 Weather proof course on RCC roof.

Learning Objectives

After completion of this unit the student shall be able to understand the following

Definition and concept of Roof, classification of roofs king post truss and queen post truss, steel roof trusses, roof coverings for pitched roofs and flat roofs, tools required to fix AC sheet and GI sheets, methods for fixing AC sheets, general requirements for roof, Weather proof course on RCC roof.
7.0 Introduction

Roof is the uppermost part of the building. Since the advent of civilization, men learnt to construct roofs to protect themselves from sun and rain. Different materials are used for roofs as per the respective needs and civilization. There is a gradual transition from sloping roofs to flat roofs. Further there is a gradual development from roofs constructed temporarily and requiring frequent replacement to roofs of permanent construction.

7.1 Definition of roofs and the concept of roofs

A roof is defined as the uppermost part of a building constructed to protect the building against rain, heat, wind, snow etc.

7.2 Classification of roofs, various types of pitched roofs, king post truss and queen post truss.

The roofs are classified into the following three categories:

(i) Flat or terraced roofs
(ii) Pitched or sloping roofs
(iii) Curved roofs

Flat or terraced roofs: A roof which is nearly flat is known as a flat roof. In this type of roof, a minimum slope is provided to drain off water. At present almost all roofs are flat roofs of R.C.C. Before the development of R.C.C., flat roofs are constructed with wood as reinforcement and lime concrete. Madras terraced roof, Bengal terraced roof and Allahabad terraced roofs are some of the different types of flat terraced roofs. Flat roofs are used for moderate rainfall.

Pitched roofs or sloping roofs: At places where there is excess rainfall or snowfall, considerable slope is provided to drain off the rainfall or snow. These are known as the sloping roofs. Basically there are three types of sloping roofs. Lean to roof, gabled roof and hipped roof.

Lean to roof: If the slope is provided in only one direction, it is known as a sloping roof. It is usually provided at the adjoining verandah of the main building. The height of the verandah is considerably reduced at one end.
Gabled roof: If the roof slopes in two directions, it is a gabled roof. In the gabled roof the opposite walls are of equal height. The height of the building and the height of the roof is raised at the centre.

Hipped roofs: If the roof slopes in all the four directions, it is known as a hipped roof. In the hipped roof all the four walls are of equal height.

Gabled roofs are further classified as couple roof, close couple roof, collar roof and double corner roof for spans between 3.0 m. and 5.0 m. If the span exceeds 5.0 m, roofs are provided with trusses. The various types of trusses are king post truss, queen post truss and steel roof truss.

Couple roof: In this type of roof, the common rafters slope upwards from the opposite walls and they meet on a ridge piece in the middle. The common rafters are firmly secure in position at both the ends. One end is secure to the ridge piece and the other to the wall plate. A couple roof is suitable for spans upto 3.6 m.
Close couple roof: In addition to the two principal rafters and ridge piece as in couple roof, a tie beam is provided to connect the legs of the common rafters. The tie beam prevents the rafters from spreading out. A close couple is suitable for spans up to 4.2 m.

Collar roof: In this roof two principal rafters and ridge piece are provided as in a couple roof. The tie beam is raised and placed at the higher level, usually 1/3 to 1/2 of the vertical height of the ridge. This roof can be adopted up to a maximum span of 4.80 m.

Double collar roof: In this roof, two collars are provided to the couple roof. One collar is provided at 1/3 of the vertical height and the other collar at 2/3 height. This can be adopted for a maximum span up to 4.8 m.
Curved roofs: The curved roofs have their top surface curved in the form of shells and domes. They are suitable for public buildings to develop architectural effects. Tajmahal and Charminar are examples of curved roof.

Trussed roofs: When the span exceeds 4.80 m and when there are no supporting walls inside, the trusses are provided. There are king post trusses and queen post trusses.

King-post truss: In this type of truss, the central post, known as king post is provided. It is placed centrally at the tie beam. It is connected at its top to the ridge piece and the principal rafters. Struts are placed connecting the centre of the principal rafters and the base of the king post. The king post is splayed at the bottom to receive the struts. Purlins are placed at the centre of the rafters connecting the other king post truss placed at a certain distance. Cleats are provided to support purlins. A king post truss is suitable for spans varying from 5 m to 8m.
Queen post truss: A queen post truss consists of two vertical members, known as queen posts. The upper ends of the queen posts are kept in position by a horizontal member known as a straining beam. A straining sill is introduced on the tie beam between the queen posts. Struts are placed connecting principal rafter and queen post. Additional purlins are supported on the queen posts. A queen post truss is suitable for spans varying from 8 m to 12 m.
7.3 Steel trusses – various parts of steel truss, panels for different spans.

For the spans greater than 12 m, it becomes economical to use the steel trusses. The arrangement and sizes of various members of the steel truss depend on the span, loading and the wind pressure.

A steel truss consists of principal rafters and a tie beam. A number of panels are arranged inside the triangular portion of the truss formed by the principal rafters and the tie beam. The number of panels = $2/3 \times S$, where ‘S’ is the span in meters. For example if the span of the truss is 12 m, the number of panels =8.

Fig 7.8 Steel trusser
The panels are arranged by providing supporting members in the truss. Depending upon the number of panels, the arrangement of the members change. For spans varying between 6m to 9 m, simple fink steel truss is provided. Howe steel truss is provided for spans varying from 9m to 12 m. Compound fink steel truss, cambered fink steel truss and compound howe steel truss is provided for spans between 12 m to 15m. Arch steel truss is provided for spans between 15 m and 20 m, while bow -string steel truss is provided for spans between 20 m to 30m. To admit light into the rooms North light steel truss is provided. In sheds of large areas north light trusses are provided.

7.4 Roof covering material for pitched roofs, flat roof and R.C.C. roof

The following factors should be considered before selecting the type of roof covering for a pitched roof:

1. Climate of the locality.
2. Nature of the building.
3. Initial cost and maintenance cost.
4. Durability.
5. Availability of material.
6. Fabrication facilities.
7. Type of roof framework.
8. Resistance to fire and heat
9. Special features of the locality.

The following are the various types of roof coverings which are commonly used for the pitched roofs.

1. Thatch: This is a very light roof covering. It is combustible. It absorbs moisture rapidly and is easily liable to decay. It is unstable against high winds. A bed of matting is provided to receive the thatch. The pitch of this room is 45 degrees. It is the cheapest form of roof and is very simple in construction. Thatch roof is used mostly in rural areas.

2. Ordinary half-round country tiles: These are used for cheap buildings. If these tiles are laid in two layers, the roof is known as a double-tiled roof. An overlap of at least 80 mm should be provided when these tiles are used. These tiles are liable to break easily. They require frequent replacement.
3. Shingles: The roof is covered with shingles made from well seasoned timber. The length of the shingle ranges from 300 mm to 380 mm, while its width range from 60 mm to 250 mm. This covering is useful in hilly areas where the wood is available easily and cheaply.

4. Patent tiles: This is a tiled roof, where patent tiles like Mangalore tiles, Allahabad tiles etc are used. These are the premium tiles having characteristic color. These tiles are more durable and they don’t require frequent replacement.

5. Trafford asbestos-cement tiles: These are made of cement and asbestos. They possess less corrugations and are laid with laps of 150 mm and 100 mm at the ends and sides respectively.

6. Eternit slates: Slates are stone slabs of area 0.125 m². These are fire-resisting, light and cool. They are not easily affected by weather. The eternity slates are available in three colors—grey, black and red.

7. Corrugated galvanized iron sheets: The galvanized iron sheets are prepared by pressing flat wrought-iron plates between rollers with grooves or teeth and then they are galvanized with a coat of zinc. These sheets are commonly called as G.I. sheets. The corrugations help to increase strength, rigidity and they permit easy flow of rain water. These are available in lengths of 1.2 m to 3.6 m, and in widths ranging from 600 mm to 900 mm, the thickness varies from 0.18 mm to 1.60 mm. They are costly and do not offer resistance to fire and sound.

8. Asbestos cement corrugated sheets: The cement is mixed with about 15 percent of asbestos fibres and the paste so formed is pressed under rollers with grooves or teeth. These sheets are called A.C. sheets. The corrugated A.C. sheets are used for factories, workshops, garages, big halls etc. They are cheap, fire resisting, light in weight, strong, tough, sound proof, impervious and durable.

**Roof covering material for flat roof**: The various types of flat roofs are Madras terraced roof, Bengal terraced roof and R.C.C. roof. In madras terraced roof teak wood joists are placed on rolled steel joists with a furring piece between them.

A course of specially prepared terraced bricks is laid diagonally across the joists. After the brick course has set, a course of brick bat concrete is laid. The concrete is well rammed for three days and allowed to set. The flat tiles are then laid over the layer of concrete.

In Bengal terraced roof, the rafters are placed at slight inclination. The battens are placed at right angles to the rafters. A course of flat tiles is then laid
in mortar over the battens. A layer of tiles or concrete is then laid over this layer and two or three coats of plaster is then laid over it.

In RCC roof, a formwork is prepared and steel reinforcement is placed over it with sufficient cover for reinforcement. Plain cement concrete with cement, fine aggregate and coarse aggregate is prepared and it is thoroughly mixed by adding water. This plain cement concrete is poured over this steel reinforcement. It is cured for a period of 21 days.

### 7.5 Tools required to fix AC sheet, GI sheet and roof covering

The following are the tools required to fix AC sheet, GI sheet and Roof covering.

- A steel tape is required to mark the length of the sheets, Overlap length of the sheets and purlin spacing.
- A plane saw is required for cutting the sheets and a tenon saw is required to cut the sheets and place them without gaps.
- A drilling machine is required to drill holes in the sheets. Wolf drilling machine or a hand drilling machine may also be used.
- As the diameter of the hole is greater than the diameter of the screw, a GI washer and a bitumen washer shall be provided.
- A screw driver and a cutting plier are required to tighten the nuts or bolts of a screw.

### 7.6 Methods for fixing of AC sheet

The following points should be observed in connection with the fixing of AC sheets.

1. The sheets should be laid with smooth edge upward and the end marked top pointing towards the edge.
2. The sheets are usually laid with an end lap of 150 mm.
3. The purlin spacing and length of sheets should be properly checked before the process of laying starts.
4. The holes for fixing the accessories must be drilled. The diameter of the hole should be 3 mm greater than the diameter of the screw or bolt to be used. A bitumen washer must be provided under the GI flat washer with each bolt or screw.
5. The sheets should be properly mitred or cut to avoid gaps where four sheets meet at lap.

6. The nuts of screws or bolts should be moderately tightened when 10 to 12 sheets have been laid. The screws or bolts on the purlin should not be tightened too much.

7. The ridge capping should preferably be secured to the ridge purlin by the same kind of bolts which are used for fixing the sheets.

8. The unsupported length of overhang at the eaves of the sheets should not exceed 300 mm.

7.7 General requirements of roof

The following are the requirements of a good and well planned roof.

1. It should be durable against the adverse effects of various agencies such as wind, rain and snow.

2. It should have sufficient insulation against sound and heat.

3. It should be stable and it should be capable of taking the loads likely to come over it.

4. It should be well drained.

5. It should have efficient water-proofing arrangement.

6. It should be fire resistant.

7.8 Weather proof course on RCC roof

All the flat roof at present are constructed of RCC. To make the roof water-proof or weather-proof the following methods are employed.

1. **Finishing**: For ordinary buildings of cheap construction, the finishing is done at the time of laying cement concrete. The finishing of flat roof is carried in cement mortar of proportion 1:4.

   2. **Bedding concrete and flooring**: In this method, the surface of the R.C.C. slab is kept rough and on this surface, a layer of concrete is laid. The concrete may be mass concrete 1:5:10 of 100 mm thickness or concrete of proportion 1:2:4 of 50 mm thickness known as bedding concrete. Over this surface flooring of Indian patent stone, tiles, or terrazzo is laid.

   3. **Mastic asphalt and jute cloth**: In this method, a layer of hot mastic asphalt is laid on the roof surface. The jute cloth is spread over this layer. Then one more layer of mastic asphalt is applied so that the jute is sandwiched...
between the two layers of mastic asphalt. The sand is sprinkled over the entire surface of the roof. For better grip, the lead sheets are inserted at the junction of parapet wall and roof.

4. **Use of water-proofing compounds:** Some water proof compounds like Pudlo, Impermo, etc., are added to the cement during construction. These water-proofing compounds prevent seepage, leakage and damp caused by the capillary absorption of the moisture in cement, mortar and concrete. Usually 10 N of such compound is added to a bag of cement. If the compound is in fluid shape, one litre of that compound is added to a bag of cement.

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**Summary**

**Classification of Roofs:** The roofs are classified as flat roofs, sloping roofs and curved roofs.

**Types of flat roofs:** The various types of flat roofs are Madras terraced roof, Bengal terraced roof and Reinforced cement concrete roof.

**Types of sloping roofs:** Lean to roof, Gabled roof and hipped roof. A lean to roof slopes in one direction only, gabled roof in two directions and hipped roof in all the four directions.

Roof trusses for a span of 3 m to 5 m are couple roof truss, close couple roof truss, collar roof truss and double collar roof truss. For spans of 5 m to 8 m, king post truss is used. For spans between 8 m and 12 m queen post trusses are used. For spans greater than 12 m steel roof trusses are used.

**Roof covering materials for pitched roof:** The various materials for pitched roof are thatch, half round country tiles, shingles, patent tiles, Trafford asbestos-cement tiles, eternity slates, corrugated galvanized iron sheets and asbestos cement corrugated sheets.

Methods of weather proof course on RCC roofs are finishing, bedding concrete and flooring, mastic asphalt and jute cloth and water proofing compounds.

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**Short Answer Type Questions**

1. Define roof.
2. List out the classification of roofs.
3. What are the various types of pitched roofs?
4. What are the various types of flat roofs?
5. Define gable roof and hipped roof.
6. List out the various types of roof trusses.
7. Mention the various types of materials used for pitched roof covering.
8. List out the various tools required for fixing AC sheet GI sheet and roof covering.
9. What are the various types of steel roof trusses?
10. What are the various methods of applying weather proof course on RCC roof?
11. Where do you provide queen post truss?
12. Where do you provide a king post truss?
13. What are the factors to be considered while selecting material for a roof?

Long Answer Type Questions

1. What are the various types of pitched roofs?
2. Draw a neat sketch of a king post truss and mention any six parts.
3. Draw a neat sketch of a queen post truss and indicate any six parts.
4. Where do you provide steel roof truss? Draw a neat sketch of a steel roof truss. Mention the various types of steel roof trusses.
5. Describe the roof coverings which are commonly used for pitched roofs.
6. Describe the roof coverings which are commonly used for flat roofs.
7. What is the procedure adopted for fixing AC sheet, GI sheet roof covering?
8. What are the methods adopted for water-proofing of RCC roof?

OJT Questions

1. Calculate the material required for various types of trusses.
2. Calculate the weight of steel reinforcement in RCC slab by measurement of lengths of the steel rods and counting them.
Structure

8.0 Introduction

8.1 Technical terms involved in stairs and staircases

8.2 Characteristics of a good stair

8.3 Various types of stairs- Straight, Quarter turn, half turn, doglegged, open well, Bifurcated and spiral stairs

Learning Objectives

After completion of this unit the student shall be able to understand the following

• Technical terms in stairs.

• Characteristics of a good stair

• Various types of stairs

8.0 Introduction

A stair is provided to afford the means of ascent and descent. Due to restriction of landed area, we are forced to go in for high rise buildings. Study of different types of stairs and its appropriate locations is absolutely necessary. Further innovations such as ramps, lifts, elevators are replacing stairs, but still stairs are most widely used.
8.1 Technical terms involved in stairs and staircases

1. **Baluster**: This is the vertical member which is fixed between string and handrail to give support to the handrail.

2. **Balustrade**: The combined framework of handrail and balusters is known as the balustrade.

3. **Stair**: A sequence of steps provided for ascent and descent between the floors or landings is known as stair.

4. **Flight**: An unbroken series of steps between the landings is known as a flight.

5. **Going**: The horizontal distance between the faces of two consecutive risers is known as going.

6. **Handrail**: The inclined rail over the string is known as a handrail. The handrail serves as a guard rail and it should be provided at a convenient height so as to give grasp to the hand during ascent and descent.

7. **Headroom**: The vertical distance between the nosings of one flight and the bottom of flight immediately above is known as the headroom.

8. **Landing**: The horizontal platform between two flights of a stair is known as the landing. A landing provides change of direction.

9. **Newel post**: This is the vertical member which is placed at the ends of strings and handrails.

10. **Nosing**: The projecting part of the thread beyond the face of the riser is known as nosing.

11. **Pitch**: The angle of inclination of the stair with the floor is known as a pitch.

12. **Rise**: The vertical distance between two successive treads is known as the rise.

13. The vertical or front member of the step, which is connected to the treads is known as a riser.

14. **Soffit**: The under surface of a stair is known as the soffit.

15. **Step**: A combination of tread and riser is known as a step.

16. **Winder**: This is a tapering step and is used to change the direction of a flight.
17. The inclined member of a stair which supports the ends of steps is known as a string.

18. **Tread**: The horizontal portion of a step is known as a tread.

19. **Waist**: The thickness of structural slab in case of an R.C.C. stair is known as a waist.

![Diagram of stair components]

**Fig 8.1 Handrails**
8.2 Characteristics of a good stair

A well designed stair should fulfill the following requirements for providing an easy, quick and safe mode of communication between the floors.

1. Design of layout: The procedure for determining the number of risers and treads is as follows.

The height of the flight is determined with regard to the position of doors, windows, verandahs etc.

A convenient height of the risers is assumed.

Number of risers = total height of the floor/height of riser

Number of treads in a flight = number of risers – 1

2. Treads and risers: In order to make the ascent and descent easy, the treads and risers of a stair should be suitably proportioned by following the rules of the thumb.

The following formulae are in cms

Rise + Tread = 40 to 45

Rise x Tread = 450

2xRise + Tread = 60

The standard values are Rise = 140 mm and Tread = 300 mm.

3. Materials and workmanship: The stair should be constructed of sound materials and good workmanship so as to impart durability and strength to the stair. The materials used for the lining of walls and ceiling of staircase should be non-combustible.

4. Width: The width of a stair should be sufficient for two persons to pass on it simultaneously and for furniture, etc. to be carried up and down the stair. The minimum width of the stair is taken as about 800 mm. For residential buildings, the minimum width of the step is 1 m. and for public buildings 1.5 m.

5. Pitch: The inclination of a stair to the horizontal should be limited to 30 degrees to 45 degrees.

6. Headroom: The provision of an adequate headroom is necessary in a good stair. Its height should preferably be not less than 2 m.

7. Flight: The number of steps in a flight should not be less than 3 and it should not have more than 12, at the most 15. Suitable landings should be provided to provide comfort and safety to the users of the stair.
8. **Winders**: If winders are unavoidable, they should be placed at the bottom rather than the top of the flight.

9. **Handrail**: When a flight consists of more than three steps, a handrail should be provided at least on one side. The height of the handrail should be approximately 800 mm.

10. **Location**: The stairs should be so located that they are well-lighted and ventilated. They should have convenient and spacious approaches. In case of public buildings the stairs should be located near the main entrance. In case of private buildings, the stair should be centrally located so as to have easy access from all rooms.

### 8.3 Various types of stairs: Straight, Quarter-turn, half-turn, doglegged, open well, Bifurcated and spiral stairs

The following are the various types of stairs

1. Straight stairs
2. Quarter-turn stairs
3. Bifurcated stairs
4. Half-turn stairs
5. Dog-legged stairs
6. Open well stairs
7. Three-quarter-turn stairs
8. Spiral stairs

1. **Straight stairs**: In case of straight stairs, all steps lead in one direction only. This type of stairs may consist of one or more flights. When the space available for staircase is long but narrow in width.

![Fig 8.2 Straight stairs](https://example.com)

2. **Quarter-turn stairs**: A stair turning through one right angle is known as a quarter-turn stairs. It consists of one flight, landing and the second flight at one right angle to the first flight.
3. **Bifurcated stairs**: If a quarter-turn stairs is branched into two flights at a landing, it is known as a bifurcated stair. This type of stair is commonly used in the public buildings near their entrance hall. The stair has a wider flight at the bottom which bifurcates into two narrower flights at the landing— one turning to the left and the other to the right.

4. **Half-turn stairs**: A stair turning through two right angles is known as a half-turn stair. It consists of one straight flight, landing and the other flight starting from the landing in the opposite direction.
5. **Dog-legged stair**: It is a half turn stairs in which two flights run in opposite directions and there is no space between them in plan. When the total width available for stairs is equal to two times the width of the steps, this type of stairs are useful. Its name is derived from the shape of its sectional elevation.

6. **Open well stairs**: It is a half turn stair, in which there is a well shape or opening between the two parallel flights in the plan. Its name is derived from its sectional elevation. These stairs are useful where available space for a stair case has a width greater than twice the width of steps.

7. **Three-quarter turn stairs**: A stair turning through three right angles is known as a three-quarter turn stair. It should have two landings. In this case an open well is formed.

![Fig 8.6 Three quarter turn stairs](image)

8. **Spiral stairs**: In this type of stair, the steps radiate from the centre and they do not have either any landing or any intermediate newel post. The flight consists of winders only and they may be continued through any number of turns. The spiral stairs are useful when the space available is limited and the traffic is less.

![Fig 8.7 Spiral stairs](image)
Summary

• A well designed stair should fulfil the following requirements
• The rise and tread selected should satisfy the following thumb rules
• Rise + Tread = 40 to 45. Rise x tread = 410 to 450. 2 x Rise + Tread = 60
• The stairs should be constructed of sound and non combustible materials.
• The minimum width of the stair should not be less than 800 mm.
• The inclination of the stair to the horizontal should be limited to 30 to 45 degrees.
• The height of the headroom should not be less than 2m.
• The minimum number of steps in a flight is 3 and the maximum number is 15.
• As far as possible, the winders should be avoided. Handrail should be provided at least on one side.

Short Answer Type Questions

1. Define the following: Stair, Flight, Landing, Rise, Tread, Riser, Pitch, Winder, Baluster.
2. Where do you provide a winder?
3. What should be the height of the hand rail?
4. What should be the minimum and maximum number of steps in a flight.
5. What should be the minimum width of the step?
6. List out the various types of stairs.
7. Mention any two types of half-turn stairs.

Long Answer Type Questions

1. What are the characteristics of a good stair?
2. What are the various types of stairs? Describe any two stairs.
3. Explain dog legged stair case with a neat sketch.
4. Explain open well stair case with a neat sketch.
Structure

9.1 Definition of form work and objectives
9.2 Requirements of from work
9.3 Material used for form work
9.4 Removal of form work
9.5 Form work for column, column footing
9.6 Failure of form work

Learning Objectives

After studying this unit the student should be able to understand about

- Form work for column and column footing
- Material used
- Removal of form work
- Failure of form work

9.1 Definition of form work and objectives

The temporary structure erected to support the concrete in required shape till it hardens and becomes self-supporting is known as form work. This also called as centering or shuttering.
9.1.2 Objectives of form work

(i) To provide a temporary supporting structure to fresh concrete in required shape.

(ii) To provide a smooth surface.

(iii) To take self weight of concrete and the impact due to vibration of concrete.

(iv) To place the reinforcement in position and to enable the worker for tying the reinforcing rods as per design including cement mortar cover blocks.

9.2 Requirements of Form work

(i) The material for form work should be easily available, reasonable cost and suitable for reuse.

(ii) The forms must be strong enough to bear the loads of concrete and workmen, the liquid pressure of fresh concrete and the impact of ramming or vibrating.

(iii) The forms must be water-proof so as to prevent the absorption of water from the concrete.

(iv) The forms must be stiff enough to have minimum deflection.

(v) The forms should be capable of providing rigid joint to prevent bulging or twisting and flow of liquid concrete.

(vi) All surface of form work should be plane to reduce the cost of surface finishing.

(vii) Forms should be capable of gradual and easy removal the completely or partially.

9.3 Material used for form work

The usual materials which are employed in the preparation of form work are steel and timber. The form work is also sometimes prepared from aluminium, pre-cast concrete on fibre glass for cast-in-situ members involving curved surfaces.

1. Steel form work: The steel is used for, work when it is desire to re-use the form work several times. The initial cost of steel work is very high. But it proves to be economical for large requiring many repetitions of the form work. The erection and removal of steel formwork are simple and it presents a smooth surface on removal.
Following are the Advantages of steel form work over timber formwork

(i) It can be re-used several times nearly more than timber formwork.

(ii) It does not absorb water from the concrete and hence, the chances of the formation of honey-combed surface and brought down to the minimum level.

(iii) It does not shrink or distort and hence it is possible to achieve higher degree of accuracy and workmanship by its use as compared to the timber formwork.

(iv) It is easy to install and dismantle and hence, there is saving in the labour cost.

(v) It gives excellent exposed concrete surfaces requiring no further finishing treatment. The surface obtained by the use of timber formwork invariably requires plastering for getting the desired finish of the concrete surface.

(vi) It process more length and is more durable than the timber formwork.

(vii) The design calculation for the steel form work system can be made precisely because of the known characteristic of steel.

2. Timber: when formwork is required for small works requiring less repetitions the timber is preferred to steel. The timber formwork is cheap in initial cost and it can be easily adopted or altered for a new use. The timber to be used as formwork should be well-seasoned free from loose knots, light in weight and easily workable with nails without splitting.

Following facts in connection with the timber formwork should be remembered

(i) The timber is to receive wet concrete. Hence the timber formwork should be neither too dry nor too wet. If it is too dry, the timber will swell and get distorted than wet concrete is placed on it. This will affect the workability of concrete and honeycomb surfaced will appear on removals of the formwork. On the other hand if it is too wet, the timber will shrink in hot weather resulting in gaps in the formwork through which concrete will flow out. Hence, the ridges will be formed on the concrete surface. It is found that a moisture content of about 20% is appropriate for the timber formwork.

(ii) The dimension of components of the timber formwork will depend upon the loads to be carried and the availability of timber section. But generally, the latter is the governing factor as the former can be adjusted by suitable spacing of the supports.
(iii) The minimum nails should be used in timber formwork and the nail heads should be kept projecting so as to facilitate easy removal.

(iv) The timber formwork proves to be economical for building with minimum number of vibrations in the dimension of the rooms. Thus, the cutting of timber pieces is brought down to the minimum.

(v) It is the common practice to sport formwork for slab in building with the timber bellies which are cut to approximate size with wedges below them to final adjustment. It leads to the formation of weak points which are seldom prevented from displacement. The timber bellies are generally not straight and they do not transmit the load axially.

The idea of using plywood as the formwork is becoming popular at present because it affords the following advantages over the timber formwork.

(i) The plywood formwork can be re-used several times as compared to ordinary timber formwork. Under normal conditions the plywood formwork can be used for 20 times to 25 times and the timber formwork can be used for 10 times to 12 times.

(ii) The plywood formwork gives surface which are plain and smooth and hence they may not require any further finishing treatment.

(iii) It is possible to cover up more idea by using large size panel and hence, there is considerable reduction in the labour cost of fixing and dismantling of formwork.

### 9.4 Removal of formwork

The operation of removing the formwork is commonly known as the stripping. The forms which can be conveniently re-used are known as the panel forms. The forms which cannot be re-used because of tier non-standard or which are meant for structures which do not require stripping are known as the stationary forms.

The formwork is removed only when the concerto has become sufficiently hard so that removal of formwork will not damage the structure. The length of time for which formwork should be kept in position depends on the following factors:

(i) Amount and nature of dead load,

(ii) Character and quality of concrete

(iii) Shape, span and situation of structure and

(iv) Temperature of the atmosphere.
In general it may be mentioned that the formwork which is merely to retain the concrete can be removed within 2 or 3 days as in case sides of a concrete beam. But when the formwork is required to carry the whole weight of concrete it becomes necessary to keep the formwork in position for a longer period. Thus the formwork in case of floors and bottoms of beams is to be removed at least after 10 days and 21 days respectively. For slabs and beams projecting in the form of cantilevers, the formwork should only be removed after making construction of the necessary counter weight to balance the cantilever action. In general, it may be stated that the formwork should be kept as long as possible because it would assist in curing.

The quality of cement used in the preparation of concrete also greatly affects the period for which the formwork is to be kept in position. When rapid hardening cement is used the formwork can be removed after 3 to 4 days and in case of high alumina cement, this period is reduced to a few hours only.

### 9.5 Formwork for column, column footing

#### 9.5.1 Formwork for Column footings

Depending upon the shape of the column footing, the formwork of suitable shape is to be provided to receive the concrete. The usual shape is square or rectangular and it is accompanied by vertical sides or steps or sloping sides.

Fig 9-1 shows a column footing with vertical sides. A box of required dimension is prepared from plank and one side of the box is made about 300 mm longer than the other. Suitable braces are provided to make the box rigid and strong.
For further security the opposite sides may be connected by wire fixed on nails before concrete is placed in the formwork. The wire will return in the concrete when formwork is removed.

Fig. 9.2 Shows a column footing with steps. It is just similar to above. The bottom box is fitted with concrete and after box is filled with concrete and after a short time, the top box is placed on the surface of the wet concrete.

Fig. 9.3 Shows a column footing with sloping sides. The bottom planks are of required vertical sides and after placing footing reinforcement, the box for side planks is placed on the bottom planks and both are suitably connected. Sometimes the concrete is placed up to the top of bottom planks is before the box of side planks is placed in position.

The column formwork consists of box prepared from four separate sides. The four of the box are held in position by wooden blocks, bolts and yokes. Fig. 9.4 shows the details of formwork for an R.C.C. column of section 300 mm x 300 mm. The important features of the formwork for R.C.C. columns are.

(i) The formwork should be designed to resist the high pressure resulting from the quick filling of the concrete.
(iii) The spacing of yokes is about one meter. But it should be carefully
determined by working out the greatest length of the formwork which can safely
resist the local coming on the form work.

(iii) Depending upon the shape of the column the box can be suitably
prepared.

(iv) A hole is generally provided at the bottom of the form work of
column to remove the debris which might have fallen before placed. This hole
termed as the cleanout hole or washout hole filled up before placing of the
concrete starts.

(v) A wash of water is given to the inside of the formwork just before
start the laying concrete.

(vi) The boxes should be designed in such a way that with little alteration,
the can be re-use 3d for column with smaller cross-section on upper floors.

(vii) In order to make the dislocation of boxes easy, the nails are kept
projecting instead of being firmly driven. Thus they can remove easy by the claw
hammer.

(viii) The wooden yokes being efficient and cheap are widely used. But
they can be replaced by the metal, clamps of suitable design.
(ix) The formwork for circular is made of narrow vertical boards. They are known as the staves and they are correctly shaped to the required curvature. The staves in turn are fixed to the yokes which are also suitably curved.

9.5.2 Form work

The form work is stairs consist of stringer, sheets, joists, bearer and vertical posts as shown in fig. 9.5

![Formwork for stairs diagram](image)

Fig 9.5 Formwork for stairs

The riser forms are supported on cleats which are fixed on stringers or walls as the case may be. The bottom edge of the resister form is chamfered so that concrete can be placed right unto the level of next riser. The sheets rest on joists which are fixed on the bearer. The vertical posts support the bearers. Suitable alteration in the formwork is made at the floor level and landing level. The treads are kept open to as to permit the filing of concrete.

9.6 Failure of form work

The safety must find the first place in the design, construction erection and stripping formwork system. As a matter of fact, the formwork design requires the same skills and attention to details as the design of permanent structure. The general rule to be observed to avoid the failure of formwork for concrete structure is as follows:

(i) The adequate reshores must be provided immediately and concurrently with stripping operation.

(ii) If high shoring is not suitably strengthened by diagonal brace there are chances for formwork failure to occur.
(iii) It should be remembered that the form are continuously supported structure and as such, they must be provided with uniform bearing at each support.

(iv) The entire work should be carried out under the strict and direct supervision of skilled persons or engineers only.

(v) The design form work should provide for possible shocks and vibrations.

(vi) The details which are difficult to perform should be avoided as in many cases, such details will not be satisfactorily performed and may become the starting point for causing a formwork failure.

(vii) The stripping of form and reshoring shoring not be carried out in unbalanced way. It will otherwise lead to unnecessary stresses in freshly laid concrete.

(viii) The wedging of post of counter-balance load compression must be carried out the extreme care so that the assembled form support remains undisturbed.

9.6.1 Maintenance of Formwork

The form after being removed from position should be carefully cleaned and stored. The maintenance of formwork is essential to re-use it several times and thus it leads to overall economy of formwork. The damaged components of formwork should be repaired and the store of formwork should be located at such place that there are minimum chances for wind, moisture etc. to have adverse effects on it.

Summary

- When concrete is placed it is in a plastic state. It requires to be supported by a temporary supports this temporary support is known as the formwork.

- Form work should provide a smooth surface.

- The material used for formwork should be easily available.

- The form works must be water proof

- All surface of formwork should be plane to reduce the cast of surface finishing.

- Forms should be capable of gradual and easy removal either completely or partially.
Short Answer Type Questions

1. Define Formwork.
2. What are the requirement of formwork?
3. Write the objectives of formwork.

Long Answer Type Questions

1. Describe the material used for preparing formwork.
2. Explain with a neat sketch the form work used for column.
3. What are the advantages of steel formwork over timber formwork.
4. Explain the arrangement of formwork for a stairs.
5. Write short note on removal of formwork.
6. Explain about failure of formwork.

On The Job Training

1. The student should visit the sites of different centering works of columns foundations and slab.
2. Record the types of formworks.
10.1 Definition of scaffolding

**Definition**: When the height above floor level exceeds about 1.5m a temporary structure, usually of timber is erected close to the work to provide a safe working platform for the worker and to provide framework is known as scaffolding or simply a scaffold and it is useful in construction demolition, maintenance or repair works.

(a) *Components parts of Scaffolding*

An ordinary scaffolding consist of the following parts
1. **Standard**: These are vertical members of the framework and they are either supported on the ground or drums or embedded into the ground.

2. **Ledgers**: These are horizontal members parallel to the wall.

3. **Putlogs**: These are transverse pieces which are placed on the ledgers and which are supported on the wall at one end. They are at right angles to the wall.

4. **Transoms**: These are putlogs, but their both end are supported on the ledgers.

5. **Braces**: These are the diagonal or cross pieces fixed on the standards.

6. **Bridle**: These is a piece which is used to bridge an opening in a wall and it supports one end of the putlog at the opening.

7. **Guard Rail**: This is rail provided like a ledger at the working level.

8. **Toe Board**: This is a board placed parallel to the ledgers and supported between the putlogs. It is provided to work as a protective measure on the working platforms.

9. **Raker**: This is an inclined support.

The various members of a scaffold are secured by means of devices such as nails, bolt, rope, etc.

### 10.2 Types of scaffolding

**Following are the types of scaffolding**

1. Single scaffolding or bricklayer’s scaffolding.
2. Double scaffolding or mason’s scaffolding.
3. Cantilever or needle scaffolding.
4. Suspended scaffolding.
5. Trestle scaffolding.
6. Steel scaffolding
7. Patented scaffolding.

**1. Single Scaffolding or Bricklayer’s scaffolding**

This is the most common type of scaffolding and is widely used in the construction of brickwork. It consists of a single row of standard placed at a
distance of about 1.20 m from the wall. The distance between the successive standard is about 2 m to 2.50 m. The ledgers are then fixed to the standards at a vertical distance of about 1.20 m to 1.80 m.

![Scaffolding Diagram](image)

**Fig. 10.1 Scaffolding, Single Scaffolding, Double scaffolding**

The putlogs with one end on the ledger and the other end on wall are the placed at a horizontal distance of about 1.20 m to 1.80 m. The braces guard rail and toe board are fixed as shown in fig 10.1 and fig 10.2. This type is also sometimes known as putlog scaffolding.

### 10.3 Shoring and Underpinning

**Definition**: Sometimes the structures are to be temporarily supported. This achieved by what is known as the shoring. It is essential for structure which have become unsafe due to unequal settlement of foundation or due to removable of the adjacent building or due to any other reason for safe structure the shoring is required prevent movements when certain additions and alteration are being carried the circumstances under which the shoring is required can be summarized as follows.

(i) Adjacent structure is to be dismantled.

(ii) Cracks developed due to unequal settlement of foundation in a wall are to be repaired.

(iii) Defective wall of building are to be dismantled and rebuilt and supports necessary to the floors roofs connected to that walls.
(iv) Large openings are required to be made in the main walls of an existing building.

(v) Walls of a building showing signs of bulging out or leaning outwards due to bad workmanship.

1. **Material**: The shoring can be carried out either in timber or in steel tubes or in combination of timber and steel tubes. The timber surface should be coated with a preservative so as to give protection against wet rot.

2. **Duration**: There is no limit for the duration of shoring and it ranges from weeks to years.

3. **Requirement**: The loads coming on shoring vary widely in nature and hence the requirement of each case of shoring be studied separately and designed accordingly.

4. **Approval**: The shoring should be carried out as per prevailing rules and regulations of the local authority and necessary approval should be obtained.

**10.3.1 Types of Shoring**

Depending on their supporting characteristics, the shores are classified into the following three categories

1. Ranking or inclined shores
2. Flying or horizontal shores
3. Dead or vertical shores.

**10.3.2 Under Pining**

**Definition**: The placing of new foundation below an existing foundation or the process of strengthening the existing foundation is known as the underpinning of foundation.

Following are the situation demanding underpinning

(i) A building with deep foundation is to be constructed adjoining to an existing building.

(ii) Settlement of existing foundation has taken place, resulting in serious cracks in the wall.

(iii) The basement is to be provided to an existing building.

(iv) The existing foundation are to be deepened so as to rest them on soil of higher power.
Points of be attended to before under pinning

Following important points should be carefully attended to before the work of under pinning commences.

1. **Shoring and Strutting**: The necessary shoring and strutting should be provided to the structure to make it safe for carrying out the process of underpinning.

2. **Examination of structure**: The structure should be carefully examined before under pinning is commenced and poor masonry work should be suitably rectified.

3. **Repairs**: It is necessary to carry out urgent repair such as grouting of cracks insertion of tie rods between walls, etc before commencing underpinning.

4. **Checking arrangement**: The levels may be marked on the structure and the movement of structure during underpinning should be checked and recorded.

5. **Expensive operation**: The process of underpinning is an art rather than a science. Due to advance made in the science of soil machines, much guess-work in underpinning is eliminated. But still remains an expensive operation.

6. **Bearing Plate**: When R.S. joist is used as needle, the bearing plate is provided a void the crushing of masonry.

**Methods of Under Pining**

Following are the methods of under pining

1. Pit method
2. Pile method
3. Miscellaneous method

10.3.3 In this method

The existing wall is divided into suitable section of width about 1.20 m to 1.50m.

The holes are then made in the existing wall. The needles with bearing plates are then inserted through these holes and supported on jacks as shown in Fig 14-2. The pit is excavated and the existing foundation is taken up to the required level. Following precautions are necessary:
(i) One section should be excavated at a time.

(ii) The alternate sections should be taken in succession.

(iii) If the length of wall is more, the underpinning is started from the middle and it is then extended in both the direction.

(iv) The proper timbering should be provided for the trench.

(v) It is desirable to carry out the new foundation work in concrete.

(vi) If space to support needles on outside is not available the cantilever needles, projecting inside and provided with fulcrums and loading, may be adopted as shown in fig 10.2.

Fig 10.2 Pit Method
Summary

**Scaffolding**: scaffolding is a temporary framework of timber or steel elements having platt forms at different levels to enable the masons to work at different heights of a buildings.

**Shoring**: Structures are to be temporary supported. This is known as shoring.

**Underpinning**: The placing of new foundation below an existing foundation is known as underpinning of foundation.

Short Answer Type Questions

1. Define scaffolding.
2. Define shoring.
3. Define underpinning.
4. Mention the types of scaffolding.
5. Mention the types of underpinning.
6. Mention the types of shoring.

On The Job Training

1. The student should visit the sites of masonry work, which are under construction.
2. Record the scaffolding work.
Structure

11.1 Technical term
11.2 Classification of Joints
11.3 Tools used in carpentry

Learning objectives

After studying this unit the student should be able to understand about

• Technical terms in carpentry
• Classification of Joints carpentry
• Tools used in Carpentry

11.1 Technical terms

The following are the technical terms commonly used in carpentry.

1. **Batten**: The narrow strip of wood which is nailed over the joints of boards is known as batten.

2. **Bead**: This is a semi-circular projection which is formed on the degrees or surface of wood. It is used at the joints of straight boards to avoid the unsightly appearance of the joint in case of shrinkage of wood. The four terms of bead namely, single quirked bead, double quirked flush bead, cock bead and cock bead with are respectively shown.
3. **Chamfering**: This term is used to indicate the taking off the edge of corner or arris of a wooden piece. It forms an angle of $45^0$ and V-joint will be formed when chamfered pieces are placed together. If the angle of chamfer is other than $45^0$, it is known as the bevel. If the chamfer does not continue for the full length of it is called a stopped chamfer.

4. **Groove**: This is a term which is used to indicate a recess formed in a of timber. If the groove is made parallel to the grain of wood, it is called the plough grooving and if the groove is made across the grain of wood, it is known as the plough cross grooving.

5. **Grounds**: These are rough wooden blocks which are fixed previously to the wall to act as an additional support for wide architraves ornamental, moulds, etc. The surface of grounds are flush with plaster and thus the act as a guide for the plastering work. The grounds are used in superior work.

6. **Housing**: This is a term used to indicate the sinking of edge of one piece of timber into another.

7. **Mitring and Scribing**: This is a term which is used to indicate a process of joining two pieces of timber at an angle. If one end of moulding is cut to suit the profile of another moulding, it is known as the scribing.

8. **Moulding**: This is a term which is used to indicate the process of formation of moulded sections. It can be done either by hand or by machine.

9. **Nosing**: The edge of portions overhanging surface is known as the nosing. This term has a slightly different meaning when used in relation to the step of a stair. A rounded has the overhanging edge semi-circular in section.
10. Planning: The process of taking off the shaving from wood with the help of plane is known as the planning. It makes the timber surface smooth and the planed of smoothened surface is known as the dresses surface.

11. Rebating: This is a term which I used to indicate the process of preparing a rectangular portion on the edge of a timber piece so as to receive another timber piece which is also similarly cut.

12. Sewing: The art of cutting of wood by means of the saws is known as the sawing.

13. Shooting: This term indicate the art of dressing of edges of timber pieces so as to make them straight and square with the face.

14. Studding: This term is applied to the fixing of small timber battens to the timber walls to which laths and boards are to be nailed.

15. Veneering: This is a term which is used to indicate the covering of entire or part of exposed surface of timber by means of veneers. The inner portion is designed to satisfy requirement and the veneers are fixed for the decorative purpose. The veneers may be laid in large sheets or into small pieces of suitable shapes.

16. Wainscot: It indicates the lining or paneling of wood on the lower part of masonry walls say for a height of about 600 mm from the floor level.

11.2 Classification of Joints

The joints are classified into the following six categories

1. Lengthening joints
2. Widening joints
3. Angle joints
4. Oblique-shouldered joints
5. Bearing joints
6. Framing joints

Lengthening joints

Those joints are employed to extend the length of a member by joining two pieces of timber. These joints are also known as spliced or longitudinal joints. The method of lengthening will depend on the situation of the member in a framed structure where such joints are common required. The usual forms of these joints are discussed below.
1. **Lapped Joint**: This is the simplest form of joint and is formed by putting the two timber pieces one over the other for a short distance and then binding them together by means of iron traps or stirrups are provided with bolts on sides for additional strength and if the member has to resist a tensile stress, the bolts passing through both the pieces may be provided.

![Fig. 11.5 Lapped joint](image1)

2. **Widening Joints**: These joints are employed to extend the width of boards or planks, which is placed edge to edge. These joints are also known as the side joints or boarding joints and they are used for wooden doors, floor etc. Table 22-1 shows a list widening joints which are commonly used.

**Widening Joints**

![Fig. 11.6 Butt joint](image2)

![Fig. 11.7 Rebated joint](image3)

![Fig. 11.8 Rebated and filleted joint](image4)

![Fig. 11.9 Ploughed and touged joint](image5)
Tables Used

Widening Joints

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of Joint</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Butt joint</td>
<td>This is also known as the straight, plain or square joint and it is used for ordinary purpose.</td>
</tr>
<tr>
<td>2</td>
<td>Rebated joint</td>
<td>This joint remains dust-proof after the shrinkage of timber.</td>
</tr>
<tr>
<td>3</td>
<td>Rebated and filleted joint</td>
<td>A small piece of wood, called the fillet, is introduced in the rebated portion. This joint is used for floors where heavy wear is expected such as factories, stores etc.</td>
</tr>
<tr>
<td>4</td>
<td>Ploughed and tongued joint</td>
<td>A fillet is provided into the grooves. This joint requires more labour. But it forms an excellent joint.</td>
</tr>
<tr>
<td>5</td>
<td>Tongued and grooved joint</td>
<td>This joint is used for work of superior nature.</td>
</tr>
<tr>
<td>6</td>
<td>Rebated tongued and grooved joints</td>
<td>This joint is used for secret nailing that is, for placing the nail heads in such a way that they cannot be seen.</td>
</tr>
<tr>
<td>7</td>
<td>Splayed joint</td>
<td>This joint is used for ordinary purpose.</td>
</tr>
<tr>
<td>8</td>
<td>Dowelled joint</td>
<td>The dowels which are small pieces of hard stone, slate Gunmetal Brass bronze or copper are used to form this joint.</td>
</tr>
<tr>
<td>9</td>
<td>Matched and beaded joint</td>
<td>This joint used to avoid unsightly appearance due to the shrinkage of timber.</td>
</tr>
<tr>
<td>10</td>
<td>Matched and jointed joint</td>
<td>This joint is just similar to above except that instead of being beaded, it is chamfered in the shape of V.</td>
</tr>
</tbody>
</table>

Fastening

The fastening which are commonly employed to secure timber joints in position are briefly described below.
1. **Bolts**: One end of the bolt is formed of a solid head and at the other end of the shank, the threads are provided on which a nut moves. The washers are flat discs of iron and they are placed under the nut as shown. The washers prevent the possible injury by nut to the timber when nut is pressed.

2. **Pins**: These are the small pieces of timber which can be used to strengthen the joint.

3. **Screws**: These are used under the following circumstances

   (i) The work is likely to be removed.

   (ii) The security of work is required without making the joint unnecessarily rigid.

   (iii) The driving of a nail is likely to split the timber.

   (iv) The work is to be done in pieces.

   (v) The joint is subjected to the vibrations.

   The various forms of screws are available and they may be of copper, brass steel or wrought iron.

   • Shows an ordinary screw.

   • Show a coach screw which has a square or hexagonal head so that a spanner can be used to turn it.

   A handrail screw which has threads at both ends. At one end a square nut is attached and the other end is provided with a circular nut slotted on the edge.
3. **Sockets**: These are the pieces of wrought or cast-iron and are used to protect the ends of timber. When sockets are placed at the feet of members, they are known as the shoes.

4. **Spikes**: These are large nails of length about 100 mm to 150 mm and they are used for heavy work.

5. **Straps**: These are bands of steel or wrought iron which can be used for to join two pieces of timber. The breadth of strap is about 40 mm to 50 mm and its thickness depends upon the stress coming upon it. The great advantage of a strap is that the timber is not required to be cut and thus the timber is not weakened.

6. **Wedges**: These are the pieces of wood which are tapered and are used for securing timber joints as in case of mortise and tendon joint. They are sometimes known as the keys and when used in parts they are termed as the folding wedges.

### 11.3 Tools used in carpentry

Table shows a list of tools required by a carpenter. The sketches of some of the tools are already given in chapter 10 of stone masonry and hence the corresponding numbers are mentioned.

#### Tools used in carpentry

<table>
<thead>
<tr>
<th>Name of tool</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Boring tools</strong></td>
<td></td>
</tr>
<tr>
<td>Auger</td>
<td></td>
</tr>
<tr>
<td>Auger bit</td>
<td>This is used for deep boring</td>
</tr>
<tr>
<td>Centre bit</td>
<td>These are used to prepare the holes of different shapes</td>
</tr>
<tr>
<td>Rose counter sunk bid</td>
<td></td>
</tr>
<tr>
<td>Screw-driver bit</td>
<td></td>
</tr>
<tr>
<td>Brace</td>
<td>A bit is attached at is lower end and hole is bored by hand press</td>
</tr>
<tr>
<td>Bradawl</td>
<td>This has a sharpened end</td>
</tr>
<tr>
<td>Gimlet</td>
<td>This is small tool used for making and boring small holes</td>
</tr>
<tr>
<td><strong>2. Cutting tools</strong></td>
<td></td>
</tr>
<tr>
<td>Compass saw</td>
<td>The various forms of saw and chisel are used to cut the timber</td>
</tr>
</tbody>
</table>
Summary

1. The term carpentry includes such forms of construction which have to resist stresses due to loads coming upon them.

2. The form joinery is used to indicate fittings art of preparing internal fittings and finishing of timber.

3. The joiner constructs timber works such as door, windows, stairs, floor boards, furniture, cupboards etc.

4. The workman also is employed for the work is known as carpenter.

<table>
<thead>
<tr>
<th>3. Hammer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claw hammer</td>
</tr>
<tr>
<td>Spall hammer</td>
</tr>
<tr>
<td>Waller’s hammer</td>
</tr>
<tr>
<td>The various forms of hammer are used to drive the nails and for forming Joints</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Marking tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bevel, Marking gauge, Spirit level Square</td>
</tr>
<tr>
<td>These tools are required to mark lines on the wood.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Planning tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bead plane, Jack plane, Rebate plan</td>
</tr>
<tr>
<td>The various forms of plane are used to make the surface of timber Smooth and to form small moldings.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Miscellaneous tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cramp, Nail punch Oil stone Pincers Pliers Screw – driver</td>
</tr>
<tr>
<td>These tools make the carpenter’s work speedy and easy</td>
</tr>
</tbody>
</table>

Coping saw  
Cross-cut-saw  
Hand saw  
Firmer chisel  
Mortise chisel  
Paring chisel
5. The joints are classified as **follows**
   1. Lengthening joints
   2. Oblique shouldered joints
   3. Widening joints
   4. Bearing joints
   5. Angle joints
   6. Framing joints

### Short Answer Type Questions

1. Define carpentry.
2. Define Joinery.
3. Define Carpenter.
4. Mention the types of Joints.
5. Write the tools used in carpentry.

### On The Job Training

1. Student should visit the site of carpentry work observe and record the different joints, tools used in carpentry.
Structure

12.0 Introduction
12.1 Plastering
12.2 Procedure of plastering
12.3 Pointing
12.4 Painting

Learning Objectives

After completing this unit the student should be able to understand about

- Purpose of plastering, pointing and panting
- Types of plastering, pointing and painting
- Procedure of plastering pointing and pointing

12.0 Introduction

Masonry structures after their construction require interior and exterior finishing or protective coatings. These finishings shall increase the life and strength of the structure and at the same time enhance the appearance. Other finishings include white washing, colour washing, painting, distempering etc. These finishing are also called as “surface rendering”.
12.1 Plastering

Plastering is the process of covering masonry walls and other structures with a plastic material called plaster or mortar. Plaster material can be made of cement and sand or lime and sand or cement, lime and sand. But now-a-days more popular plaster is made with cement and sand, also known as cement mortar due to many of its advantages.

12.1.1 Objectives of plastering

The principle of objectives of plastering the surface are

1. To provide an even, smooth, regular, clean and durable surface at the same time it improves the appearance.
2. To protect the surface from atmospheric influences by acting as a protective coating.
3. To hide or conceal the defective workmanship.
4. To cover up and used inferior quality of material and the joints formed in masonry work.
5. To provide a base for decorative finishing such as colour washing, distempering, painting etc.
6. Plastering also projects the surface against dust and vermin nuisance.

Some of Technical Terms:

1. Rendering: Application of plaster and finishing.
2. Daubing: operation of filling in hollows in the surface of a wall with mortar to get fairly level surface before actual plastering in the surface.
3. Hacking: The process of making a surface rough by chiseling so as to provide a key for plaster work.
4. Cracking: The development of one or more fissures in the plaster not due to structural defects.
5. Crazing: The development of series of hair cracks on the finished surface, known as “Map Crazing” when it forms a irregular pattern over the surface affected.

Preliminary work Before Plastering

Construction operation such as completing the construction of masonry, the encasement of steel columns and beams etc. Requiring subsequent plastering,
shall be programmed that they are sufficiently cured and dry to receive the plaster without further damage to plaster or decoration on the plaster.

**Preparation of surface**

1. **Roughening**: The roughening of the background improves the bond of plaster. This is particularly important in case of soffit ceiling. A smooth surface shall be roughened by wire brushing if it is not hard or by hacking if it is hard. All joints shall be thoroughly raked. After roughening, care shall be taken to moisten the surface sufficiently before plastering. Otherwise the freshly exposed dry surface may absorb considerable amount of water from the plaster.

2. **Cleaning**: The surface to be plastered shall be thoroughly brushed to remove dust, loose particles of mortar etc., or efflorescence where it has occurred.

3. **Daubing**: Daubing shall be necessary where the background is very uneven that unevenness cannot made up in regular coat of plastering. The process of daubing consist in filing the holes and depression with mortar of the same mix as per the first coat. The patches of plaster thus done are left rough so that the subsequent coat plaster would stick to it.

4. **Wetting**: The surface shall be wetted evenly before applying the plaster. Care shall be taken to see that the surface is not to dry as this may cause lack of adhesion or excessive absorption of water from the plaster. As far as possible, the plaster work shall be done under shade.

5. **Control of cracking**: In case of discontinuity in backgrounds the two portions shall be separated by a near cut or groove at the junction. Where such cutting or grooving is not participle the plaster at such location by reinforced by providing a suitable scrim of jute or wire gauge etc.

6. **Control of surface crazing**: Sufficient time intervals shall be provided between successive coats so that each under goes its shrinkage before the next coat is applied. Care shall be taken to prevent rapid drying of the final or finishing coat.

**Tools for plastering**

Following tool are generally used for the plastering work

(i) **Gauging trowel**: This is the ordinary trowel and is useful for applying mortar to mouldings, corners etc. It has a pointed or bull-nosed end.

(ii) **Float**: This is tool is used for to spread the mortar on the surface. It is made of thin tempered steel. It is also known as the laying trowel. The wooden float is known as the Skimming Float and sis used for
final or finishing coat of plaster. A float provided with nails projecting to make zigzag lines on the plastered surface so as to form a key for the subsequent coat.

(iii) **Floating rule**: This tool is used to check the level of the plastered surface between the successive screeds.

(iv) **Plumb bob**: This tool is very much useful in forming screeds in the same vertical plane.

(v) **Miscellaneous tools**: In addition to the above tools, other tools such as brushes, spirit, level, set squares, straight, edges etc. are used for the plastering work.

### 12.1.2 Method of Plastering

The plastering may be applied either in one, two or three coats. It is the cheapest form of construction that plaster is applied in one coat. For work of ordinary nature, the plaster is applied in two coats and for works of superior quality, the plaster is applied and three coats.
12.2 Procedure of plastering

As per A.P.D.S.S, cement mortar (1:4) shall be used to plastering work unless it is mentioned specifically. Generally the ingredients i.e., cement and sand are proportioned on volume basis and then mixed thoroughly. Each bag of Portland cement weighs 50 kg., and by volume each bag O.P.C is equal to 0.35 cu meters. In other word, weight of cement for a volume of 1 cu meter is equal to 1440 kg. Wooden boxes of standard sizes shall be used for mixing sand with cement.

Mixing: For large works, mixing shall be done preferably in a mechanical mixer by adding cement adding cement and sand in specified proportion and mixed thoroughly in dry state. Water shall then be added gradually and wet mixing continued at least for 3 minutes. Care shall be taken not to add more water than that required to prepare the mortar of suitable working consistency.

The plastering with cement mortar shall be done in the same manner as described in lime mortar plastering. But final rendering shall be applied immediately after plastering is completed.

Neat Portland cement slurry with a cram like consistency is applied as thinly and uniformly as possible with trowel and rubbed smooth.

12.2.1 Plastering with cement mortars, two coats 20 mm thick with sponge finish.

Cement mortar for the first coat shall be prepared in specified proportion as described in previous case. The mortar for the second coat shall be made with fine sand, passing through sieve of 150 and 600 microns of the specified proportion.

Application of first coat: The first coat of cement mortar in specified proportion shall be applied as mentioned in lime mortar plastering except that cement mortar 17 mm thick shall be applied. The plastered surface after floating is gain raked to provide a proper bond for the second coat.

Application of Second coat: Cement mortar with fine sand as indicated above shall be prepared in the form of thick cream like consistency. This is applied over the first coat surface prepared with trowel to a thickness of 3 mm. It is then floated with a long wooden float to make the surface true. Then the entire surface is lightly rubbed with wet sponge and then daubed with sponges squeezed dry to get the required finish.

When it is not possible to apply the second coat when the first coat is green, the first coat shall be cured for at least two weeks before it is permitted to fry. Before the second coat is applied, the surface shall be thoroughly scrubbed
and washed clean to remove dust and other loose particles. The surface shall be thoroughly wetted before applying the second coat. The finish surface shall be cured for a minimum period of two weeks.

### 12.3 Pointing

Pointing is defined as the finishing of masonry joints with a rich mortars and in decorative manner. Pointing is applied when it is desired to exhibit the material of the masonry, when the material used in the masonry is capable of resisting the atmospheric action.

#### 12.3.1 Objects of pointing

Following are the main objects for providing pointing and plastering to the exposed surfaces:

(i) To improve the appearance of the structure as a wheel and to give smooth surface.

(ii) To protect the exposed surface from the effects of atmospheric actions.

(iii) To rectify the defective workmanship or a conceal inferior materials.

#### Types of Pointing

(a) Flush pointing

(b) Raised and cut pointing

(c) Line or groove pointing

(d) Struck pointing

(e) Tuck pointing

(a) **Flush pointing**: The mortar shall be pressed into the joints and shall be finished and level with the edges of bricks tiles or stones so as to give a smooth appearance. The edges shall be neatly trimmed with trowel and straight.

(b) **Raised and cut pointing**: Raised and cut pointing shall project from the wall facing with it edges cur parallel so as to have a uniformly raised band about 6 mm raise and width 10mm. The pointing shall be finished to a smooth but hard surface.

(c) **Line or groove pointing**: The joint shall be initially formed as for flush pointing. While the mortar is still green, a groove of specified size and shape shall be formed by running a groove forming tool along the centre line of
the joints. The operation shall be continued till a smooth and hard surface is obtained.

In case of coursed rubble or brick masonry, the vertical joints shall also be finished in a similar way. The vertical lines shall make true right angles at their junction with the horizontal lines.

![Fig 12.6](image)

(a) Flush Pointing    (b) Raised and cut Pointing    (c) Line or Groove pointing

(d) **Struck pointing**: In this type the face of the pointing is finished inclined. The upper edge of the pointing plaster is pressed inside the masonry by about 10 mm and lower edge is finished level with the masonry.

(e) **Tuck pointing**: In this type of pointing a rectangular groove is formed at the center of the joint. This groove is lastly filled with white lime putty by keeping is slightly projecting outside the finished surface of the pointing plaster.

The pointing shall be kept wet for about seven days. During this period it shall be suitably from all damages.

**Method of pointing**: The pointing is carried out as follows

(i) The mortar of the masonry joints to be covered by pointing is raked out at least to a depth of 20 mm.

(ii) The dust from the masonry joints is removed by the brushes.

(iii) The surface is then washed with clean water and it kept wet for a few hour.

(iv) The mortar is then carefully placed in desired shape in these prepared joints the mortar is placed by a small trowel and it is slightly pressed to bring it into close contact with the old interior mortar of the joint.
(v) The finished surface is well-watered for a period of at least 3 days, if lime mortar is used and 10 days, if cement mortars is used.

### 12.4 Painting

Painting is the process of applying a coat over the surface of wood, metal or plaster to provide a thin coating. This coating gives good appearance to the surface and protects it from decaying and corrosion.

**Objects**

1. To protect wood from decaying.
2. To prevent corrosion in metals.
3. To protect the exposed surface from harmful effects of atmospheric agencies.
4. To provide decorative and pleasing appearance to the painted surface.
5. To make the painted surface hygienically safe and clean.

#### 12.4.1 Painting of plastered surface

Painting shall be avoided on a freshly plastered surface for at least 12 months to ensure that the surface becomes dry including internal moisture, the surface shall be white or colour washed in the first instance otherwise the alkalies present in the plaster will destroy, bleach and discolour the paint and also prevent it from drying. Preparation of plastered surface depends upon the type of paint to be applied over the surface. On drying, the new plastered surface shall be treated with dilute sulphuric acid or hydrochloric acid and then washed with water.

The surface shall then be given a coat of sizing (glue mixed with a water) to fill up all the cracks and reduce suction of paint. The surface may also be given a coat of boiled linseed oil before applying the paint. After the oil has been absorbed by the surface, filling of cracks if any shall be done preparing a paste of chalk powder plaster of Paris and the paint to be used. The entire surface shall then be smoothened by rubbing it with sand paper.

The surface thus prepared shall generally be given four coats of the paint. The first coats of the paint consist of white lead and boiled linseed oil. The third coat may be white lead tinted to approach the desired colour and mixed with a raw or boiled linseed oil. The last coat may consist of large proportion of turpentine oil. The surface is thus finally finished with a good brush as explained in the case of wood work.
Readymade or ready mixed paint are also available in market which can be applied directly on the newly plastered surfaces.

**Painting old plastered surface**: If the oil paints is firm and sound it shall be cleaned of grease smoke etc. and then all dust, dirt and loose particles of paint shall be removed.

If the old paint is badly blistered and flaked, it shall be completely removed by using and type of paint remover. If any portion of the walls shows signs of dampness, the cause shall be investigated and the damp surface shall be properly treated. A thin coat of white lead the damp surface shall be properly treated. A thin coat of white of lead if required shall be applied on the wet or patchy portion of the surface before painting is undertaken.

Application of new paints shall be carried out as specified in previous case i.e. in similar way as described for new plastered surface.

### 12.4.2 Painting on different surface

The process of painting on the nature if the surface to be painted. A brief description of painting on each of the various surface is given below:

1. **New wood work**: Normally four coats of paint are required for new woodwork.

   **The process of painting is carried out as follows**

   (i) The surface of woodwork is prepared to receive the paint. For satisfactory working it is necessary that the woodwork is sufficiently seasoned and it does not contain more than 15 percent moisture at the time of painting. The surface of woodwork is thoroughly cleaned and the heads of nails are punched to a depth of 3 mm below the surface.

   (ii) The surface of the woodwork is then knotted.

   (iii) The printing coat is then applied on the surface of new woodwork. Generally the printing coat is applied before the woodwork is placed in position.

   (iv) The process of stopping is then carried out.

   (v) The subsequent coats of paint, namely, under coats and finishing coats are then applied on the surface. The extreme surface should be taken to see that the finishing coat presents smooth and even surface and that no brush marks are seen on the finished work.

2. **Repainting of woodwork**: If the paint on the old wood work has cracked or has developed blister, it is to be removed. If the surface has become greasy, it should be cleaned by rubbing down sand paper or fine pumice stone.
The old paint can also be removed by applying any one of the following three paint solvents.

(i) A solution containing of one part of soft soap and two parts of potash is prepared and one used to wash the surface. The paint dissolves and the surface becomes clean.

(ii) A mixture consisting of one part of soft soap and two parts of potash is prepared and one part of quickness is then added afterwards. This mixture is applied on the surface in a hot state and allowed to stay for about 24 hours. The surface is then washed with hot water.

(iii) A mixture consisting of equal part of washing soda and quicklime is brought to a paste form by adding required quantity of water. It is applied on the surface and kept for about an hour. The surface is then washed with water.

After removing old paint from the surface, the wooden work is painted as in case of painting on new woodwork.

3. New iron work and steelwork: The surface of iron or steel to receive the paint should be free from rust, grease, dirt etc. The suitable equipment such as wire brushed, scraper, etc. are used to remove all loose marks etc. From the surface the water with caustic soda or lime is used to removed grease. The cleaned surface is provided with a film phosphoric acid. This film protects the surface from rust and it also facilities the adhesion of paint. The coats of paint are then applied.

The paint suitable to iron and steel surface should be selected for each coat. The finishing coat should present a smooth finish and precaution should be taken to avoid the presence of brush marks on the final painted surface.

4. Repainting old iron work and steelwork: The old surface should be thoroughly cleaned by the application of soap-water and if grease if present, it should be removed by washing the surface with lime and water. If it is necessary to remove old paint, the surface be burnt, usually by a blow lamp and then old paint should be scraped off or dissolved and removed by using any paint solvent. After the surface is thus prepared, the painting is carried out as in case of new ironwork or steelwork.

Summary

- Plastering is the process of covering walls and other structures with a binding material called plaster or worker.
- Plaster material can be made of cement and sand, also known as cement mortar.
• Pointing is used to denote the finishing of mortar joints of either stone masonry or brick masonry.

• Main objectives of pointing
  • To improve the appearance of the structure
  • To provide the exposed surface from the effects of atmospheric actions
  • To rectify defective workmanship

• Main objectives of plastering
  • To provide an even, smooth, regular, clean and durable surface
  • To improve the appearance
  • To protect the surface from atmospheric actions
  • To provide a base for decorative finishing such as colour washing, distempering, painting etc

**Tool used for plastering**

1. Pump bob
2. Float
3. Floating rule
4. Trowel
5. Brushes
6. Spirit ravel
7. Straight edges

**Methods of plastering**

**Mastering may be applied**

• One coat
• Two coat
• Three coat
• Types of pointing
• Beaded pointing
• Flush pointing
• Recessed pointing
• Grooved pointing
• Struck pointing
• Tuck pointing
• Vee-pointing

**Short Answer Type Questions**

1. Define plastering.
2. Define pointing.
3. Write the objectives of plastering.
4. Mention methods of pointing.
5. Define the following.
   (i) Rentering
   (ii) Daubing
   (iii) Hacking
   (iv) Cracking
   (v) Crazing
6. Define painting.
7. Mention the objects of paintings.
8. Explain flush pointing.

**Long Answer Type Questions**

1. Explain the method of preparation of surface masonry before plastering.
2. Explain the method of plastering write cement mortar one coat 12 mm thick.
3. Describe the method of painting on wood surface.
4. Describe the method of painting on metal surface.
On The Job Training

1. The student should visit the sites of building construction and observed the plastering and pointing works of masonry.

2. The student should visit the sites of painting work and wood works of new and old.

3. And also the student should maintain the record of different site visit
# Structure

13.0 Introduction  
13.1 Bull Dozer  
13.2 Concrete mixers  
13.3 Cranes  
13.4 Pully Blocks  
13.5 Pumps  
13.6 Winches  
13.7 Excavator

## Learning objectives

After studying this unit the student should be able to understand about various types of construction equipment and their purposes.

## 13.0 Introduction

In the construction work, construction equipment of different type are required to suit the nature of work. These equipment are to be collected and kept in workable condition so as not to obstruct the progress of work. The success of a construction project entirely depends upon the choice of mechanical equipment and if the choice is proper, the work can be completed in short time.
with less cost. As a matter of fact, easy availability of good mechanical equipment proves to be an asset of any civil engineering project.

**The knowledge of construction equipment is required to**

(i) Make construction planning  
(ii) Prepare work table  
(iii) Select right type and number of equipment  
(iv) Run all the equipment continuously, economically and efficiently and  
(v) Improve speed, quality, consistency and economy of construction by selecting the suitable equipment.

**Various types of construction equipment**

Following are the different types of construction equipment  
1. Excavating equipment  
2. Earth compaction equipment  
3. Hauling equipment  
4. Hoisting equipment  
5. Conveying equipment  
6. Pumping equipment  
7. Concrete construction equipment  
8. Drilling equipment  
9. Road making equipment

**13.1 Bulldozer**

(i) **Purposes of bulldozer**: A bulldozer is very useful equipment and can be used in the construction work for the following purposes:

(a) To clear the site of work  
(b) To make the land level  
(c) To prepare pilots roads through mountains and hard ground and  
(d) To excavate the material and haul for a distance of about 100 meters
13.2 Concrete mixers

(a) Tilting Drum Mixer: These are small capacity mixtures. In this 3 cu. m of concrete mix can be prepared in one hour.

(b) Non-Tilting Drum Mixer: This is available in sizes varying from 0.15 cu. m capacity of mixing concrete. In this the mixer will rotate continuously in one direction only.

(c) Continuous mixer: This mixer works continuously and the ingredients are fed regularly without interruption to the mixer movement. This mixture has a capacity of 10 cu. m to 20 cu. m of concrete per hour.

13.3 Cranes

The three operations involved in the working of crane are as follows

(i) Hoisting, i.e. raising the load from its position and lowering it at its point of destination.

(ii) Luffing, i.e. moving the boom in or out as required.

(iii) Slewing i.e. moving the boom in arc as seen in the plan.

Depending upon type of mounting, cranes can be classified as

(a) Crawler mounted
(b) Truck mounted
(c) Wheel mounted
Each type claims certain advantage hence, depending upon the nature of work, suitable type may be selected.

Some of the important type of cranes which have come into use are

(i) Derrick Cranes
(ii) Goliath cranes
(iii) Swing Jib Cranes
(iv) Tower cranes:

**Fig. 13.2 Derrick Cranes**

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### 13.4 Pulley blocks

They are to change the directions of ropes and to raise greater loads with less effort. The blocks are made of wood and depending upon the number of sheaves or pulley-wheels, they are termed as single, double, etc, pulley blocks.

The various forms of pulley blocks are

i. Differential pulley block
ii. Spur gear pulley block
iii. Worm gear pulley block
13.5 Pumps

The pumping equipment is required for various purposes in the construction work such as lowering water table, furnishing water for jetting, removing water from pits, de-watering cofferdams, foundation grouting etc. The various types of pumps suitable for specific condition are available. Extreme care should be taken to select particular pump for the work. The condition for which pumping equipment is required are properly studied and analysed before making any recommendation.

The pumps are classified as

1. Air lift pumps
2. Centrifugal pumps
3. Displacement pumps
4. Miscellaneous pumps

13.6 Winches

A winch is a mechanism in the shape of a cylinder or drum, over which rope or chain is wound. If a winch is used only for raising or lowering, it is sometimes referred to as hoist. Winches may be operated either manually or mechanically. Winches should be enough capacity to accommodate the longest length of rope likely to be wound over them.

13.7 Excavators

An excavator is the oldest type of machine which removes earth. It performs its work moving the earth while the main unit is stationary. The little effort is required to move the dead weight of earth in a vertical plane. The excavator in common use are of the following five types.

(i) Back trench hoe excavator
(ii) Clamshell excavator
(iii) Power shovel excavator
(iv) Dragline excavator
(v) Skimmer excavator
Summary

- The knowledge of construction equipment is required to make construction planning, select right type and numbers of equipment and to run equipment continuously and efficiently.

- Bulldozers are used in the construction work to clear the site of work, to make land level and to prepare roads through mountains and hard ground.

- Depending upon the nature of work suitable type of crane may be selected.

- Some important types of cranes are derrick crane, goliath crane, tower crane.

- Pumping equipment is required for the purpose of lowering water table, removing water form pits, de-watering cofferdams foundation grouting etc.

- Pumps are divided into four groups
1. Air lift pumps
2. Centrifugal pumps
3. Displacement pumps
4. Miscellaneous pumps

- Excavator is used for moving dead weight weight of earth in a vertical plane.
- Excavator may be mounted on crawler wheels or trucks
- Concrete mixers are the following types
  (a) Tilting drum mixer
  (b) Non-Tilting mixer
  (c) Continuous mixer
- Pulley blocks are used to change the direction of ropes and to raise greater loads with less effort.
- A winch is a mechanism in the shape of a cylinder or drum over which rope or chain is wound.

**Short Answer Type Questions**

1. List out various types of construction equipment.
2. Write the purposes of bulldozer.
3. Write the use of Roller.
4. Mention of types of cranes.
5. Write the types of cranes.
6. How the pumps are classified.
7. What is the use of excavator?
8. Write the purposes of pulley blocks.
9. Explain winches.

**Long Answer Type Questions**

1. How the construction equipment are classified?
2. Write short notes on (a) Crains (b) Excavators.
3. Write short notes on (a) Concrete mixers (b) Pumps
4. Write short notes on (a) Concrete mixers (b) Cranes.
7. Write about concrete mixers.

**On the Job Training**

1. Students should visit the sites construction work.
2. Observe different equipment which are used for construction work.
3. Maintain the records and write the function of each equipment.